NAVAL ARTILLERY TO 1550

Its design, evolution and employment

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NAVAL ARTILLERY TO 1550.

An analysis of its design, development and employment.

Naval warfare played a major part in the history of North West Europe, and since the sixteenth century this form of combat has been dominated by artillery.

From its first recorded employment at sea in the fourteenth century until the 1550s, artillery underwent continual change in design and method of employment, brought about by improvements in production techniques and an increasing awareness of the capabilities of artillery.

Although a substantial amount of historical investigation has been carried out on naval artillery, little or no attention has been paid to developing a typology for early naval weapons and using this as a means by which to study the significance of gun construction and means of employment, then relating it to the increasing wealth of archaeological evidence available. As far as one can ascertain, no comprehensive survey of the subject of early naval artillery has been printed. This thesis is an attempt to fill this gap.

This thesis comprises an analysis of gun types, construction methods, deployment at sea, mounting and means of employment in order to determine the effectiveness and limitations of early naval artillery, and to explain its failure to achieve a more significant role in naval combat before the late sixteenth century.

Sources will comprise collections of artillery, including weapons recently recovered from historical wrecks (eg. the Mary Rose) and the historical and contemporary literature on the subject, including some unpublished sources. This evidence will be re-assessed in the light of new archaeological discoveries.

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(c). I hereby certify that the candidate fulfilled the conditions of the Resolution and Regulations appropriate to the degree of M.Litt. of the University of St. Andrews and that he is qualified to submit this thesis in application for that degree.

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Introduction.

Naval warfare played a major part in the history of North West Europe, and since the sixteenth century this form of combat has been dominated by artillery.

From its first recorded employment at sea in the fourteenth century until the 1550's, artillery underwent continual change in design and method of employment, brought about by improvements in production techniques and an increasing awareness of the capabilities of artillery.

Although a substantial amount of historical investigation has been carried out on naval artillery, little or no attention has been paid to developing a typology for early naval weapons and using this to study the significance of gun construction and means of employment, then relating it to the increasing wealth of archaeological evidence available. As far as one can ascertain, no comprehensive survey of the subject of early naval artillery has been printed. The following pages are an attempt to fill this gap.

This thesis comprises an analysis of gun types, construction methods, deployment at sea, mounting and means of employment in order to determine the effectiveness and limitations of early naval artillery, and to explain the failure to assign it a more significant role in naval combat before the late sixteenth century. Sources will comprise collections of

artillery, including weapons recently recovered from historical wrecks (eg. the "Mary Rose") and the historical and contemporary literature on the subject, including some unpublished sources. This evidence will be re-assessed in the light of new archaeological discoveries.

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CHAPTER 1. GUN TYPOLOGY AND TERMINOLOGY.

Introduction.

In order to determine the importance of early naval artillery in naval warfare, ship design and contemporary naval thought, the weapons themselves need to be analysed, together with contemporary sources dealing with artillery. The need to establish some form of typology is paramount in order to form a basis upon which later research can be based, and contemporary references to types of artillery may be applied.

Although typologies have been constructed in the past for guns dating from the mid-sixteenth century onwards, little attention has been applied to earlier guns. This chapter proposes a method of typology for fifteenth century guns based upon surviving examples of weapons. Similarly, it proposes an early sixteenth century typology, based both on surviving weapons and on contemporary written sources. By means of these typologies, it is intended to illustrate the development of early naval ordnance from its first use at sea until the mid-sixteenth century, thus filling an important gap in our knowledge of naval artillery.

This chapter is arranged in four sections. First the problems encountered when attempting to construct early gun typologies are discussed. Next, the development of

artillery until the mid-fifteenth century is reviewed in order to provide a historical background to the first typology, concentrating on the early use of naval artillery. This is followed by a method of typology for fifteenth century gun types, based upon surviving examples. Finally, this early sixteenth century gun typology concentrates on contemporary methods of classification, and the use of these gun types at sea.

1. The problems concerning the establishment of a typology.

Any attempt at establishing a typology of fifteenth and sixteenth century gun types immediately encounters obstacles in several areas, as the researcher becomes entangled in a seemingly impenetrable web of conflicting sources, technical anomalies and loosely applied terminology. The main problems encountered are listed below, together with a brief explanation of the reasons behind the confusion.

a. Written Sources.

A wide variety of source material is available, including several works on the subject by contemporary European authors (1). Indeed, the problem is compounded rather than elucidated by these sources in that conflicting evidence and inaccuracies amongst the primary sources have led to error and further confusion amongst secondary ones.

Many sixteenth century treatises on artillery were written in a theoretical and idealistic style that often obscured the real state of the subject at the time, and the writers' arguments were often based on premises that later turned out to be false. Other principal sources,

such as inventories and reports, suffered from the common fault that the writer was either inaccurate or vague in his writing, leading to confusion, especially in the area of nomenclature. The ordnance tables contained in a number of these treatises are summarised in Appendix C.

b. Variety of weapons.

Gunnery during the period was more of an art than a science, in that no clear specification of gun type was accepted, and gunners and gunfounders showed a remarkable individuality, defying the establishment of any such standardisation (2). Guns were classed in very general groups, but individual manufacturing techniques by different gunfounders, as well as their artistic licence and choice of metal composition all contribute to cause considerable confusion. Further, there is the desire of later artillery experts to attempt to catalogue earlier gun types into their own contemporary gun classifications. This variety renders difficult any attempt to study existing weapons and fit them into the broad categories of gun types (3). A further illustration can be seen in the confusion of the writers of later treatises when attempting to bring a semblance of order to the subject.

c. Nomenclature.

Biringuccio, when dealing with sizes and types of guns, wrote in 1540:"it does not matter what their names may be except to know their sorts and kinds" (4), emphasising the problems created by nomenclature, even for contemporary gunfounders.

A perplexing variety of terms for the same gun is the salient problem with which the researcher is initially confronted. Moreover, he is introduced to further problems by the fact that similar terms became misused or placed in different contexts. Since certain gun terms fell into disuse, later to be revived, and, quite often, to be used in an entirely different context, one is made aware of these confusing perplexities, enhanced by the use of incorrect nomenclature by later historians. A cautious approach has to be adopted; one has to pay particular attention to the date of the reference, as well as to its source. An example of this is provided by the term "serpentine", used as a general term in Germany throughout the period. In England and France it gradually became a name for a general type of light gun before being used to describe a larger piece in the later Tudor navy.

d. Technical Treatises.

During the later years of our period, treatises exist which attempt to classify gun types and catalogue their characteristics, such as the works of Sheriffe, Bourne and Norton. The problem arises in that the lists are often at variance with each other in a number of respects, causing further confusion.

Gun length expressed as a multiple of calibre is almost always mentioned, and the degree of uniformity encountered is surprising. However, naval pieces were often shorter than their land equivalents. These "bastard" pieces caused an overlapping of gun types and made a clear catalogue of gun types, based solely on calibre, impossible. In addition there was a general tendency for guns to be increasingly fortified during the sixteenth century, thus gradually increasing the overall weight of guns during this period. This is thus a further factor which hampers accurate classification and dating (6).

Windage, the "allowance for vent", has generally been accepted in English sources as 1/4 of an inch from Lucar's time onwards, but continental sources vary, as do earlier English treatises, such as that written by Sheriffe. This windage also cannot be reconciled with German sources which give a windage of as little as 1/20 of an inch. Other sources make windage vary in relation to shot size, and although an allowance of 5% seems

normal, it becomes clear that any reference to gun bore must be examined with caution. The dating of the written source could thus affect the size of bore given for each type of gun.

2.The development of late medieval artillery.

The early development of artillery can be divided into three distinct phases. The first, from 1313 to about 1370, represents a period when guns were experimental, a psychological novelty more than a weapon of war, and gun sizes and offensive power were minimal. This was followed by the "bombard" era, from 1370 to about 1450, when gunfounders were concerned with increasing gun size in order to increase performance. This resulted in the construction of enormous guns which were powerful yet of limited value apart from their use as siege weapons. By 1450, the limitations of bombards had forced gunfounders to increase the effectiveness of smaller pieces, thus field ordnance and guns with a more rapid rate of fire could be produced. It was only in this third phase that the employment of shipborne artillery had any significant effect on naval warfare.

If we ignore the possible use of gunpowder weapons by the Mongols in the mid thirteenth century, as depicted on the Mongol Invasion Scroll (7), the first recorded mention of the new weapon comes in 1313, when the Ghent city records mention that "in that year the use of bussen was first discovered in Germany by a monk", possibly the Berthold Schwartz of German legend (8). Records for the following year state that "bussen

met kruyt" (guns with powder) were exported to England (9), so the Flemish merchants must quickly have seen the potential of the new weapon. Bussen (or buchsen in German) refers to guns, the term possibly originating from the Greek "boubos" meaning a deep, hollow sound.

The earliest written evidence for the actual manufacture of ordnance is found in the Florentine ordinances of 1326 which order the appointment of superintendents for the manufacture of brass "cannae", along with iron balls and arrows (10). An illustration of such a weapon, from Christ's College, Oxford, dated 1327, graphically explains why such early guns were called "vasi" by the Italians and "pot de fer" by the French (cf. figure 1). Artillery reputed to have been employed at the Battle of Crecy (1346) may have been of this type (11), but its lack of military value is no doubt reflected in the lack of contemporary reference to it.

Cart-mounted guns were used in the field and not just as siege weapons, by 1350, a date close to the first reference to shipboard artillery, which will be dealt with later. These small weapons were grouped together on carts, an arrangement described by Froissart as a "ribaudequin": three or four guns bound together on a cart (12). These have also been called "chars de guerre", or "kraiks of war". The Burgundian army of 1411 was said to have been accompanied by 2000 such carts, perhaps a textual error for 200 (13), so this

form of gun mounting remained in use during the bombard era.

These early guns were small. They were constructed of iron or bronze, weighed between 20-40 pounds, and fired shot of no more than 4 pounds weight. After 1370, however, although bronze weapons were still produced, wrought-iron guns became more common (14). The large pieces mentioned by Froissart appear from the illuminations to have been fairly small, mounted individually on wooden beds, with a length equal to the height of the gunners pictured next to them. As other written sources rarely give details of size, it is impossible in most cases to differentiate between handguns and larger pieces since both types of weapon shared the same nomenclature. As it appears that guns before 1370 were relatively small in comparison with later weapons, handguns may have been viewed as larger guns "in miniature", and were thus employed in the same manner (15).

During the 1370s a change occurred in the pattern of gun development. Before this period, guns were seen as having limited military value: Froissart, for example, attaches more importance to torsion powered siege engines for use in siege warfare (16). The development of the bombard occasioned a change in outlook, heralding a new phase in the development of artillery. Froissart mentioned bombards as well as cannon at the siege of Quesnoy (1340), but the name does

not occur in any contemporary document until 1360 (17), and so was probably a later term used in an earlier context. It was not until the late fourteenth century that the term bombard was used to refer specifically to a heavy gun (18).

In 1372, Lille gunfounders were commissioned to construct a great gun, costing one pound, English. A decade later, a bombard which cost twenty times more was constructed by the city, in a period without marked inflation (19). A Venetian bombard of 1376 was "of a size never before seen", and a contemporary weapon constructed in Nuremburg could, according to the makers, "demolish a thick wall at a thousand paces" (20). Giving due allowance for exaggeration, these weapons represent a marked improvement on weapons of the time, and the new power, with its intrinsic prestige and military value, heralded what can be regarded as a revolution in military thinking and in contemporary attitudes towards artillery.

By the mid-fifteenth century a sufficient variety of weapons existed to necessitate sub-division, and the emergence of light weapons mounted on field carriages at the same period, heralded the arrival of the third phase in the development of artillery. The number and variety of light guns in use by the mid-fifteenth century is illustrated by an English verse written between 1457-60, which refers to "bombards, guns, serpentines, fowlers, crappaudes, culverins and other sortis moo than eight or

nine" (21). It is therefore clear that, by 1450, the bombard formed only a part of a range of different gun types.

Before the sub-division of fifteenth century weapon types is examined, the references concerning the employment of these weapons at sea need to be considered. Surprisingly little evidence exists concerning shipborne artillery before the end of the fifteenth century. Some broad trends, however, can be identified. It appears that the French employed naval guns from the beginning of the Hundred Years War, as a Norman fleet assembling off Le Havre and Harfleur in 1338 contained a royal galley, owned by the city of Rouen which was armed with a "pot de fer" (22). A long accepted theory that English ships were armed with guns in the same year has proved to be unfounded (23), but the possibility remains that artillery was used during the naval battle off Sluys (1340), where Walsingham claims "gunnae plures cum quant pulveris" were employed (24). From these early references to the employment of artillery, it may be supposed that the numbers of guns carried by ships gradually increased during the century, although no records to support the theory exist before 1372, the start of the bombard era. There may then be a link between the changes in outlook brought about by bombards, and the increasing willingness to use artillery at sea. Certainly, shipborne artillery is mentioned with increasing frequency after 1370.

The Carlton Ride rolls from 1372 onwards list guns of brass and iron, handguns and chambered pieces employed on English royal ships (25). A French vessel built for Jeanne de Vienne, Admiral of France, was armed with thirty-four "improved guns", and was possibly the first royal warship to be armed with a substantial complement of artillery; presumably many were hand-held pieces. Italian sources state that the Venetians mounted guns on their galleys in 1379 (26), and Froissart mentions that the Genoese fleet of 1390 contained "brigandines, well furnished with artillery" (27).

A number of weapons, recovered from the sea near the Island of Walney, were dated by nineteenth century historians to the reign of Richard II (1377-99), with no firm evidence to substantiate this dating, apart from a reference to vessels lost off the island during his reign. If the dating is correct, and these guns were indeed employed as part of a warship's armament and not carried as cargo, then they indicate that substantial weapons could be mounted on vessels by the late fourteenth century (28). However, the nature of the evidence concerning gun deployment discussed in Chapter 3, indicates that a fifteenth century date would appear more realistic for these artefacts, and until the origin of these weapons can be established, little can be deduced from them.

English records of the early 15th century indicate

the more widespread employment of naval ordnance, as shown in an indenture by the Clerk to the King's Ships in 1410 (29) which lists the ordnance carried by three Royal vessels, as follows:

The Christopher of the Tower	: 3 cannon de fer,
	5 chambres
The Bernard of the Tower	: 2 cannon de fer,
	sanz estuff.
The Mary of the Tower	: 1 cannon de fer,
	1 cannon ov brass,
	1 chambre.

A Danish inventory of 1406 lists not only guns, but also stocks of powder, wadding, linstocks and firepans (30). A vessel of approximately the same period, wrecked off the Danish island of Anholt, produced several large wrought-iron guns, which are described in Chapter 3. However, these weapons, apparently carried as ship's armament rather than as cargo, indicate that substantial guns could be carried on fifteenth century vessels, substantiating the Walney Island evidence, although indicating a possibly later date for the wreck.

In a battle off Harfleur in June 1416, the English fleet under John, Duke of Bedford, met a joint French and Genoese fleet. The fighting was reported to have been: "man to man, lance to lance, arrow to arrow, stone to stone and iron masses to lead", a clear indication of the employment of differing types of artillery, forming part of a complete fighting unit: as a weapon to

participate in, or at least to precede the melee between opposing ships (31).

Similarly, Lancastrian accounts record a rise in the number of guns carried, illustrating the increasing armament of Royal vessels such as the Henry Grace a Dieu, and also list the armament of Genoese ships captured by the English in 1417 and pressed into the king's service (32). Of the five Genoese prizes listed, all had three or fewer guns, all breech-loading. As these vessels were listed as carracks, this could be seen as typical of the armament of the armed merchant vessels of the period. The royal ships, owned by the king and used as merchantmen in time of peace, boasted a heavier armament of up to six guns (33). From this it can be seen that even royal ships had an artillery armament that could have been of little use in combat apart from disrupting the enemy prior to a melee action.

By the start of the third phase in the development of artillery, guns were thus well established as part of the armament of European warships. Shipborne artillery had no problems of mobility to hinder their use, and the rate of fire of swivel mounted chambered guns ensured that artillery would play an increasingly important role in naval warfare. From 1450 on, there is increasing documentation relating to naval armament, especially in England under Henry VII, and the picture becomes far less fragmentary. This presumably further reflects the growing importance of artillery as a weapon of war. For

the first time, in 1466, an English record mentions the deployment of guns within a vessel (34). This indicates that the role of artillery was seen as part of an integrated system of naval weaponry, and that the deployment of these weapons was attaining greater importance.

In conclusion, all the evidence available supports the theory that the importance of guns at sea reflected the changing attitude towards artillery generally. By 1450, technological progress in the development of lighter pieces of artillery facilitated the mounting of such weapons on ships. During the late medieval period, vessels gradually increased the number of weapons they carried, if not the size of these guns. By 1485, generally acknowledged as marking the end of the medieval period, artillery formed the most significant part of a warship's armament.

3. Towards a fifteenth century gun typology.

The fifteenth century proved to be a crucial period in the development of artillery, but when attempting to understand this development, the researcher is faced with the bewildering plethora of terms and descriptions mentioned earlier. Research is also hindered by the appendage of later names to earlier guns, especially by late nineteenth and early twentieth century historians (35).

Furthermore, other countries used a differing nomenclature for identical weapons, while German chroniclers frequently named their guns after means of employment or type of shot fired, rather than by any reference to the gun itself (36). The problems created appear so insurmountable that rather than risking error untangling the web, ordnance authorities from the Royal Armouries, Tower of London and from the Mary Rose Trust have contemplated abandoning accepted nomenclature altogether and prefer to use a typology based upon gun appearance (e.g. "tube gun") (37).

This approach has certain distinct advantages over a system based largely on an interpretation of nomenclature for weapons of this period. The proliferation of gun types during the last quarter of the fifteenth century creates problems, and during this

later period the greater amount of source material available means that a greater level of classification is required. It would be foolhardy to rely excessively on the nomenclature of the period. For this reason the following typology has been adopted for fifteenth century guns, based upon gun size, mounting and means of employment, together with a general description of these gun types. Contemporary nomenclature can then be applied to this framework where clear associations are apparent.

This typology is summarised below.

Muzzle-loading guns.

1. Large Muzzle-Loading Gun (LM)
2. Medium Muzzle-Loading Gun (MM)
3. Small Muzzle-Loading Gun (SM)

Breech-loading guns.

4. Bed Mounted Chambered Gun (BC)
5. Swivel Mounted Chambered Gun (SC)

This section is entitled "towards a fifteenth century gun typology". The emphasis on "towards" is because the sample from which the information concerning these weapons was taken was a small one. For example, under 100 wrought-iron swivel-mounted chambered guns are known to exist in European museums. The establishment of a firm typology depends upon the accurate measured recording of a far larger sample than is at present

available.

It is hoped that with the increase in maritime archaeological activity, more examples of these weapons can be added to the sample, thus increasing the accuracy of the results.

In the description of gun types, reference is made to gun bore and gun length. Gun bore is the width of the "inner tube" or mouth of the gun (excluding chamber width, which is always less than the width of the barrel). Gun length is defined as the internal length of the gun. This is measured from muzzle to touch-hole, so in the case of chambered guns, this would include both the barrel and the chamber. Unlike the later period under study where more accurate definition is available, no clear statement can be made concerning any standard ratio of gun length : gun bore. Any statement on these lines would entail a far more detailed examination of the individual gun types. The size of the sample precludes this. Similarly, the relationship between gun bore and the thickness of the wall of the gun is problematic with wrought-iron guns in that thicknesses are variable along the length of the gun. Ruth Brown and Robert Smith of the Royal Armouries are currently undertaking a more detailed examination of bombards, and a study of this closely defined group may provide some correlation between the three factors mentioned above.

1. LARGE MUZZLE-LOADING GUN (LM)

These may be defined as weapons usually of wrought-iron built-up construction, although bronze examples also exist. Guns of this group are defined by being weapons with a bore of over 20 centimetres, and are usually from 240 to 360 centimetres long, although some sixteenth century examples could have measured as much as 600 centimetres. Shot used could be either stone or iron.

Two types of large muzzle-loading guns can be identified. The first sub-group (LM 1) comprises guns of wrought-iron built-up construction, which were in common use from the 1370.

The second sub-group (LM 2) contains guns cast in bronze, a form which probably appeared during the mid-fifteenth century.

This group mainly contains the gun type known as the "bombard". Weapons of this name were essentially siege guns, and as such were unsuitable for use at sea, although they were employed on ships in the early sixteenth century (38). These pieces were relatively immobile, slow to reload and difficult to aim, thus their value outwith siege warfare was mainly psychological. The term bombard (hauptbuchse in German) is a fairly common one when used in reference to large weapons, but popular histories often made the error of implying that such weapons were breech loading, with a

screw-fitting breech chamber (39).

Existing examples of such weapons include "Mons Meg", the Dresdener "Faule Magd" and the "Burgundian Steinbuchse" in Basle (40) (Figure 2).

2. MEDIUM MUZZLE-LOADING GUN (MM)

This group comprises guns of similar form and construction to the LM group, but smaller, and with less destructive power. These guns are characterised by having a bore of between 8 to 20 centimetres, and examples have been found with a length of 300 centimetres. These weapons may fire either iron or stone shot. Four types of medium muzzle-loading guns may be identified. The first sub-group, (MM 1) consists of guns constructed from wrought-iron. The second sub-group (MM 2) is similar to the first, with the exception that guns of this sub-group show indications that they were first constructed as chambered weapons, and were converted at a later stage by blocking off one end of the barrel, forming a muzzle-loading weapon. The third sub-group, (MM 3), comprises medium sized cast-bronze muzzle-loading pieces, thus being similar to LM 2. A final group, (MM 4), consists of weapons constructed from either iron or bronze, which have a small length:bore ratio, in the manner of eighteenth century mortars.

The term "bombardelle" may apply to guns belonging to sub-groups MM 1 to 3. Problems arise however from Spanish references to later bombardelles which were breech-loading. Some fifteenth century sources suggest that "bombardelle" was a term used in reference to weapons with similar characteristics to "bombards", but of a smaller size (41). This definition therefore places them in the MM group. "Mortar" may be an appropriate modern term to attach to guns of sub-group MM 4, but little contemporary evidence can be found to prove that this nomenclature was used during the fifteenth century to refer to this form of weapon. Indeed the parameters of sub-group MM 4 would include the early weapon form referred to as "pot de fer", which pictorial evidence indicates, was fired on a low trajectory, unlike that of a mortar.

Existing examples of this gun group may be found amongst the Burgundian ordnance, now held in Swiss museums, and in the Royal Armouries, London (42), (Figure 3).

3. SMALL MUZZLE-LOADING GUN (SM)

This gun group consists of guns with a bore of less than 8 centimetres. Originally of similar construction to larger wrought-iron built-up guns, it has been suggested that some fifteenth century examples of these weapons

were made using cast iron, and smooth wrought iron examples have been recorded in Germany (43). A large number of guns of this group are distinguishable by their barrel, which is of a disproportionate size in relation to its bore, often possessing a length:bore ratio of between 20:1 and 30:1. Guns of this group may fire either iron or lead shot.

Within this group four sub-groups may be defined. The first such sub-group, (SM 1) comprises wrought-iron built-up guns, and may possibly include weapons converted in the manner of MM 2, although no surviving examples of such weapons have been located in European museums. The second group, (SM 2), consists of smooth wrought-iron or cast-iron weapons. The next sub-group, (SM 3), contains guns of this type that may be held by hand, or hooked over a parapet or ship's bulwarks. The variation of form within this sub-group is immense, however, a detailed typology of all forms of fifteenth century handguns is outwith the scope of this thesis. The reason for their inclusion here is that some of these weapons were of a similar size to contemporary swivel-mounted chambered guns and thus may have been mounted and operated in a similar manner. The fourth sub-group, (SM 4) comprises cast-bronze weapons, which appeared during the late fifteenth century.

The term "culverin" has been widely used in reference to this type of gun, as has "serpentine" in German sources, and some guns of sub-group SM 3 were given the

name "coelvrine a main". Excluding references to hand-held weapons, the term "culverin" was used in connection with field carriages by the mid fifteenth century, and culverins formed the main part of the battlefield artillery of the Dukes of Burgundy (44). This gun type may therefore be further characterised by the fact that they could be mounted on field carriages. Examples can again be found in the Swiss museums, and also Brussels (45), (Figure 4).

BREECH LOADING GUNS.

4. BED MOUNTED CHAMBERED GUN (BC)

These weapons are of similar size and construction to wrought-iron muzzle-loading guns, but are open ended, and have a separate breech-chamber, used to hold the charge at the end of the barrel. Indeed, authorities from the Royal Armouries, London, have used the term "tube gun" to refer to this group (i.e. a hollow gun, with a hole at either end of the chamber) (46). The German term "kammerschlange" or chambered gun is an ideal term to cover a variety of similar gun types, with variations in size and form equal to the range of muzzle-loading weapons covered by groups 2 and 3

outlined above. Guns of this group may have a bore of up to 24 centimetres, and could be of a similar length to equivalent muzzle-loading weapons. These guns could fire stone, iron, or in some cases lead shot, and were associated with one or more breech-chambers. All known examples of this group have been of wrought-iron built-up construction. Guns of this group were employed at sea, and among surviving examples are the guns mentioned in connection with the sites off Anholt in Denmark and Walney Island in England.

This group may be divided into three sub-groups. The first two sub-groups comprise guns with a bore of over 8 centimetres, (BC 1) consisting of weapons with a length : bore ratio of over 12:1, and the second sub-group, (BC 2), composed of shorter weapons, with a smaller length : bore ratio. The third sub-group, (BC 3), comprises guns with a bore of 8 centimetres or less.

The term "veuglaire" was apparently used in connection with guns of this type, as was "crappaudes", but no clear evidence can be furnished to indicate whether these terms referred to different sizes of chambered weapons. By the end of the century this group included several distinct types, such as "murderers"and "slings". As more information exists about these types, the terms may more readily be associated with known groups of weapons, and are thus dealt with in detail in the following section.

Surviving examples of this gun group include weapons

found in the Tojhusmuseet, Copenhagen, the Royal Armouries, London, and Swiss Museums (47), (Figure 5).

5. SWIVEL MOUNTED CHAMBERED GUN (SC)

This group of weapons is so named because of its normal mode of operation on swivelling pin mounts. These guns are associated with a breech-chamber, usually of the "beer mug" type, which was fitted into a shaped cradle at the end of the barrel, and could be trained by means of a tiller projecting from the rear of the weapon. Guns of this type found in museums usually have a gun length of around 100 centimetres although a larger group are found measuring around 150 centimetres. This length would then be increased by the size of the back of the chamber support and the tiller. They were mounted on ships rails or ports, on wagons (as depicted in illustrations of Hussite wagons), or mounted on field carriages, either singly or grouped together (48). Guns in this group could fire stone, lead or iron, usually in the form of scatter shot, although more conventional shot could also have been fired by some swivel weapons (49).

These weapons may be divided into four sub-groups. The first subgroup (SC 1), is comprised of weapons, whose characteristics include a wrought-iron hooped hall and an open framework to hold the chamber. The second

(SC 2) groups together all wrought-iron swivel guns with a smaller length : bore ratio than SC1, thus having a more short, fat appearance, and probably including swivel guns designed to fire stone shot. The third group, (SC 3), is characterised by guns either of wrought-iron built-up or smooth wrought-iron construction, with either a smooth or a hooped hall and an enclosed framework to support the chamber. This includes weapons with a partly enclosed breech framework. A fourth group (SC 4) includes bronze swivel guns came into use during the sixteenth century.

Nomenclature for these light weapons has proved to be problematic in that the contemporary term most commonly used in their context is "serpentine", which can be confused with German "serpentines" (the culverins mentioned earlier), and serpentine handguns, so named because of their "serpentine-shaped" firing lever (50). The term "falcon" has also been used to denote this form of gun, and confusion arises if these are compared with sixteenth century guns of the same name. To some extent, the two terms may have been interchangeable: a naval inventory of 1496 makes no distinction between "falconis and littel serpentines" (51). Whether this indicates that falcons were regarded as smaller than serpentines is unclear. Certainly, both refer to the same general type of small breech-loading weapon.

Existing examples of this group include weapons in the Deutches museum, Nurnberg, the Rotunda museum,

Woolwich, and the Barmouth museum, Wales (52), (Figure 6).

4. An early sixteenth century gun typology

For the purpose of establishing a typology of sixteenth century guns, a number of the problems discussed in Section 1 can be avoided by the adoption of one particular form of contemporary nomenclature. Different nations used different terms for guns of the same type, and the detailed listing of these would prove confusing. For this purpose, the form of nomenclature found in sixteenth century English sources has been adopted. Where continental names and descriptions are at variance with those used by English writers, these differences will be mentioned, although in a number of cases a direct comparison is not always possible.

Although several systems of gun classification were adopted throughout Europe, it must be stressed that these were merely basic parameters, used to facilitate gun description and grouping within the limits of their class and type (cf. figure 7). Guns that were similar to certain types but not covered by the parameters of that type were common, and classified under the title "bastard" guns. These were especially common where the need to modify the type for a particular function was apparent, as was the case at sea, where a shortened gun would be preferable because of limited deck space.

These general parameters, or gun types, were usually grouped into classes of similar weapons, at least by the

mid-sixteenth century. Although a typology suffers from the same small sample of surviving guns mentioned in the previous section, this can be supported and strengthened by the theoretical gun descriptions in contemporary artillery manuals. The non-standardisation of production and national variations combine to make the theory often different from the reality. Thus contemporary treatises can be used as rough guides for the establishment of a typology, where leeway must be given for considerable variations from the theoretical norm.

The class groupings and specifications, listed for the majority of the following gun types are derived from the classification of John Sheriffe (53). Although his treatise is undated, gun types and sizes indicate that it was written in the period between 1550 and 1570. This rather circular dating method is further supported by biographical evidence. Thus, of all the detailed English treatises available, his work was the one written nearest the period under study. Where his gun specifications prove to be greatly in variance with other English or continental sources, these differences are discussed. Gun types and classes that were regarded as obsolete before the time of Sheriffe have also been included.

Due to the lack of information concerning earlier types, they cannot be commented upon with as much accuracy, and specifications given for these weapons are

based upon those provided by Carr-Laughton (54).

As Imperial measures were used to provide the parameters of these gun types in contemporary English treatises, all measurements are given using the Imperial system.

Gun Classification.

- Cannons
  - Basilisk
  - Cannon
  - Demi-Cannon
- Culverins
  - Culverin
  - Demi-Culverin
  - Saker
  - Minion
  - Falcon
  - Falconet
  - Robinet
- Port Pieces
  - Bombard
  - Curtow
  - Murderer
  - Sling
- Perriers
  - Stone Shotted Guns
- Swivels
  - Serpentines
  - Fowlers
  - Misc. light guns

Cannon Class.

a). BASILISK.

Bore: 5"/7.5"

Shot: 15.25/53.3 pdr.

Weight: 4000/5500 lbs.

Length: 11-12'

Lth:Bore: 15-18:1

Loading: Muzzle-loading

Basilisks were heavy guns, characterised by their long length and large bore, and were used on land throughout the century, primarily as siege weapons. They had the reputation of being "the most deadly guns of the Serpentine class", and indeed German sources refer to similarly sized guns as "cannon serpentines" or "great serpentines" (55). Sheriffe also called this form of weapon a "cannon serpentine", his "basilisco" being a lighter weapon (weighing 4000 pounds), so it is possible that, by the late sixteenth century, the term basilisk was used to refer to a different type of gun, while the German form of nomenclature was used to describe the older piece. The gun term "basilisk" possibly has an Italian or Spanish origin and was not directly adopted by English gunners, probably because the weapon was rarely used by them. These weapons were

made exclusively from bronze.

A number of French galleys carried "basilisks" as their main centre-line armament during the Anglo-French war of 1512-13, as did Venetian and Ottoman galleys of the period. However, the only recorded employment of the weapon on a sailing vessel of the period was on the Scottish Great Michael in 1513, when Lindsay of Pitscottie, writing over a century later and using unspecified sources claims she carried "three great basils, two behind in her deck and one before" (56). "Basilisks" would have been highly unsuitable for employment at seadue to their great weight and size, even when mounted in galleys, and indeed their use at all may have been on an experimental basis. If they were carried on the Great Michael it was possibly as a form of status symbol. The fact that they are not mentioned in connection with shipboard use after 1513 supports the comments about suitability.

b). CANNON

Bore: 8-8.5"

Shot: 60-66 pdr.

Weight: 6-7,000 lbs.

Lth:Bore: 12-16:1

Loading: Muzzle-loading

The term "cannon" encompassed more than one gun type. The main variant, the "demi-cannon" is listed seperately, but the class also included "cannon royals" as well as "bastard" weapons, and this variety is reflected in the different parameters given by Sheriffe for these guns. Although the term "cannon" was used throughout Europe, it often referred to different sizes of weapon. For example, the French canon listed in the edict of Henri II in 1550 stated that the gun fired a 33 pounder shot, thus being of a similar size to the English "demi-cannon" type. Similarly the canon listred in Spanish inventories of the late sixteenth century also referred to a gun equivalent to the "demi-cannon". It thus follows that the definition of the term "canon" varied throughout Europe, and could be used in reference to a gun weighing from 4000-7000 pounds. However, by adopting the English system of nomenclature, these guns could at least be broken down into two general classes. Although primarily a land weapon, "cannons" were used at

sea, and were introduced into the Tudor navy before 1540. The fleet inventory of that year records that they were carried on the two royal galleys (although one of these could be a galleass), as well as the 450 ton Peter, and the 1500 ton Henry Grace a Dieu (57).

Apart from their presence on the Great Galley and the prestigious Henry Grace a Dieu, these were not carried in great numbers, so appear to have possibly been considered too cumbersome for use at sea, where "bastard cannons" and "demi-cannons" would have been more suitable.

c). DEMI-CANNON

Bore: 6.5"
Shot: 30 pdr.
Weight 4000 lbs.
Length: 8-9'
Lth:Bore: 15-18:1
Loading: Muzzle-loading

This gun type was rather more suitable for naval use than its longer namesake, being lighter and shorter weapons. Guns of the approximate size and calibre of

"demi-cannons" as recorded by Sheriffe include French canons and moyenne canons, Spanish canon and canon de batir, and also the "bastard cannon"recorded by Sheriffe was also more similar to the "demi-cannon" than the "cannon". From this it can be seen that the English definition of a "cannon" was at variance with continental definitions, and thus the "cannon" mentioned in continental sources should rather be likened to the English "demi-cannon" than be confused with the larger piece. Weapons of this kind were cast in bronze during this period, as it is considered unlikely that English cast-iron gunfounders were able to produce weapons of this size before 1550, although they appear to have been in naval service in the 1560's. The dating of the early cast-iron gun in Pevensey castle is still in doubt, while work on early cast-iron gun production and supply is currently being undertaken by the Wealden Iron Research Group and the Royal Armouries.

"Demi-cannons" appear to have been increasingly used at sea during the sixteenth century although at leat in the Tudor fleet they were still only deployed in small numbers when the 1540 inventory was compiled. It is noteworthy that at the time of this inventory, approximately the same number of "demi-cannons" were carried in the Tudor fleet as "demi-culverins", and even individual ships had on average similar numbers of each weapon on board. This may indicate some form of tactical policy, as it seems unlikely that this parity

of weapons carried was the result of a system of random deployment of guns within the fleet.

Culverin Class

d). CULVERIN

Bore: 5.5"
Shot: 17.3 pdr.
Weight: 4500 lbs.
Length: 8.5-10'
Lth:Bore: 20-25:1
Loading: Muzzle-loading

The term "culverin" is thought to have originated from the Italian "colubrina" or Latin "colober", meaning snake, and thus may be linked to the German "serpentine" gun family (58). The image produced by the name is of a long, slim gun, and when compared to weapons of the "cannon" family this is indeed an accurate impression. The term "culverin" was used during the fifteenth century to refer to light field weapons, and this association may have continued into the sixteenth century. The grande coulverine listed in the French edict of 1550 could be drawn by seventeen horses, thus

setting it apart from the train of more immobile siege guns. The "culverin" of Sheriffe's list is of an approximately similar size to the French grande coulverine and the Spanish culebrina, being recorded as being 15 pdr. and 12 pdr. weapons respectively. It must be emphasised that these parameters were merely contemporary guidelines for classification, and an individual Spanish culebrina might indeed be larger than a similarly named English weapon. These weapons were cast in bronze.

"Culverins" were relative late-comers to the ranks of sixteenth century naval ordnance. As only six "culverins" were listed in the inventory of the Tudor fleet in 1509-15, (and three of these may have been "demi-culverins"), this period may represent an experimental phase when these cast-bronze pieces were being evaluated, and their performance related to equivalent breech-loading weapons. By the time of the Tudor inventory of 1540, the number of "culverins" carried by the fleet had only increased by one gun, while two or more "demi-culverins" were employed for each culverin. It thus appears that the experiment was unsuccessful, and the shorter form of the "culverin" family guns were preferred for naval use. Similarly, few culebrinas appear to have been carried by the Spanish Armada of 1588, and none have been recovered from excavated sites, while several medias culebrinas were recovered, these pieces being roughly equivalent to

"demi-culverins".

Evidence from the Mary Rose excavation suggests that this form of gun was used as a broadside weapon, deployed in the lower gundeck or somercastle.

e). DEMI-CULVERIN

Bore: 4.5"
Shot: 9.3 pdr.
Weight: 3400 lbs.
Length: 8.5-9'
Lth:Bore: 21-24:1
Loading: Muzzle-loading

This weapon classification was clearly introduced in order to be able to differentiate between the larger guns of the "culverin" family, but the term "demi-culverin" appears to have been an exclusively English one. Theoretically, Spanish culebrinas were of a size between the English "demi-culverin", firing a 12 pdr. shot while the Spanish medias culebrinas was approximately similar to the "demi-culverin", firing an 8-12 pdr. shot. The French coulverine batarde was a lighter piece and fired a lighter shot than the English "demi-culverin", as did Sheriffe's "bastard culverin".

It must be noted that these sizes were theoretical, and gun sizes and weights were so varied during tjhis period due to non-standardisation of production techniques that any arbitrary division between such gun types would be difficult. Theory is often very different from reality, especially in gun production. These guns were of cast-bronze construction, although some cast-iron guns may have been used after 1545. Certainly, cast-iron pieces were in naval use by 1568, as the spanish inventory of the Jesus of Lubeck demonstrates (59).

Although this gun type was in use on land by 1514, it was not yet recorded as in use at sea. However, these weapons were introduced into the Tudor fleet before the 1540 inventory, and formed a substantial part of the bronze broadside armament of the Tudor fleet. Similarly, medias culebrinas were used extensively in the Spanish Armada, and four such weapons provided the principal armament of the El Gran Grifon. It is only through increasing the sample of guns available for examination through the medium of maritime archaeology that the theoretical descriptions of guns like these can be fully substantiated by hard evidence. It is worth noting also that Spanish guns of the "demi-culverin" typehad a higher length : bore ratio than the "demi-culverins" listed by Sheriffe, being in the region of 30-35:1. Although the Armada campaign was fought over forty years after the 1540 inventory was written, it does illustrate that the introduction of this type of

bronze gun into warships was not exclusively a Tudor practice.

f). SAKER

Bore: 3.5"

Shot: 5.3 pdr.

Weight: 1400 lbs.

Length: 8-9'

Lth:Bore: 24-30:1

Loading: Muzzle-loading

Sakers were characterised by their length, having a large length : bore ratio. This gun length also appeared to increase during the sixteenth century, producing extreme examples of the design, such as the "great saker" known as "Elizabeth's pocket pistol", which is over 3330 centimetres long (60). While the specifications given by Sheriffe are of a weapon firing a 5.3 pdr. shot, other sources place this gun in a group whose shot weight ranged from 5 to 9 pounds, although the majority of weapons appear to have fired shot contained in the lower half of this range. "Sakers" recovered from La Trinidad Valancera Spanish Armada site or from the late sixteenth century Teignmouth "galley"

sie were weapons firing a shot weighing between 5 and 6 pounds. Guns belonging to the upper half of this grouping might appear similar to "demi-culverins", and in some cases might only be identified by their larger length : bore ratio. Lighter "sakers" were also cast, and Spanish media sacres and English "half sakers" would belong to this category, both firing a shot weighing between 3 and 4 pounds, thus overlapping the "minion" group. All guns of the "saker" class would have been cast from bronze, at least until 1543.

"Sakers" were first deployed in the Tudor fleet during the twenty-five years between the two Tudor fleet inventories (1515-1540), and this gun type was increasingly mentioned in Tudor naval inventories as the sixteenth century progressed (61). The length of the weapons would make them difficult to deploy as broadside armament, where the weight of the shot fired would be small compared with other broadside guns. However, these factors would not hinder the use of this gun type as part of a galley's armament, either deployed as a centre-line gun of a light galley (as probably was the case with the Teignmouth gun), or as part of the secondary galley armament on larger vessels. The principal advantage that the type may have had over other types might be its range. Thus it appears that the ideal place to site such a weapon would be in the bow or the stern, as a chase piece. This assumption is supported by a comparison of the Tudor inventories,

where "sakers" appear to have replaced "slings" and "falcons", weapon types already used as stern pieces, indicating that at least on major warships, "sakers" did not form part of the main broadside armament.

g). MINION

Bore: 3.25"
Shot: 4 pdr.
Weight: 1000 lbs.
Length: 6.5-7.5'
Lth:Bore: 24-26:1
Loading: Muzzle-loading

This gun type was really a continuation of the "saker" group, and could more accurately described as a "demi-saker" type. The light "sakers" mentioned above would fall into this category, as both English "half-sakers" and Spanish medias sacres were approximately similar to the "minion" specifications given by Sheriffe. Weapons of this type have been recovered from the Spanish Armada wrecks El Gran Grifon and the Girona, and also from the Teignmouth site, where they probably formed the secondary galley armament of a lightly armed vessel.

This gun type was first mentioned in a naval context in 1515, and it appears that it continued in naval use throughout the sixteenth century, especially on smaller ships, as reflected on late Tudor fleet inventories. "Minions" were also listed as part of the armament of the Jesus of Lubeck, captured by the Spanish in 1568 (62). The role of these weapons is unclear, although they may have been used in the same chase piece manner as "sakers", their lighter weight allowing their use on smaller vessels, or in the castle decks above the heavier "saker" chasers.

h). FALCON

Bore: 2.3-2.5"

Shot: 2.25-4 pdr.

Weight: 660-800 lbs.

Length: 7'

Lth:Bore: 30-34:1

Loading: Muzzle-loading

This gun term was mentioned earlier, in the context of fifteenth century swivel guns. These early weapons would have weighed no more than 500 pounds, and would thus have been of a similar size to the fauconneau type mentioned in the French edict of 1550. This French type was of a similar size to the "falconet" type described by Sheriffe, indicating that the term "falcon" may well come to refer to a heavier gun type during the early sixteenth century. The French edict also described a faucon as weighing 700 livres in 1550. If one considers that a "falcon" is described as weighing 885 pounds in 1595, then this supports the theory that gun weight increased during the century (63). This increase would have been particularly pronounced with these smaller weapons. Despite this increase in weight, it appears that the term "falcon" was used to refer to a very specific type of gun, as all English ordnance lists are in general agreement over the size, bore and weight of

the type. This agreement over the description of the type is supported by French and German sources (64). These continental sources also provide examples of the extensive use of the "falcon" as a field weapon, where its small weight and hence its mobility made it highly suitable for use on the battlefield. The edict of Henri II records that the faucon could be moved by three horses, compared with the seventeen horses required to transport a grande coulverine. English sources also mention "great falcons", and in 1515 two were deployed in the waist of the Gabrielle Royal, mounted on wheel carriages. These pieces were introduced before the deployment of "sakers", so the reference may have been an early example of the deployment of that type of weapon. Carr-Laughton estimated that these two pieces would have fired a 6 to 9 pdr. shot, and therefore were equivalent to the largest of the "saker" group. Certainly these guns could not be grouped with contemporary "falcons". Guns of this type were constructed from cast-bronze, although cast-iron "falcons" were carried on a French vessel as early as 1568, so presumably English warships may have carried similar guns before this date. Late fifteenth century "falcons" were constructed from wrought-iron, and some of these weapons may have still been in use during the first decades of the sixteenth century.

The "falcon" appears to have been deployed extensively in the Tudor fleet listed in the 1509-15

inventory, and if Pittscottie can be believed, the type was also carried in the Scottish Great Michael. However, a comparison between the Tudor inventories of 1509-15 and 1540 indicates a drop in the number of "falcons" carried. This may well be an example of the more specialised use of the term during the sixteenth century, the later definition possibly excluding earlier wrought-iron guns of a similar size. No indication is given concerning the role of these weapons in a sailing vessel, although in 1568 the inventory of the Jesus of Lubeck records two brass guns of the Sheriffe's "falcon" size, mounted in the bow and on the upper deck (65). This may indicate that these light pieces were used in the castles, although the Jesus of Lubeck's castles were lowered before the 1568 inventory in order to improve her sailing qualities.

i). FALCONET

Bore: 2"

Shot: 1.25 pdr.

Weight: 500 lbs.

Length: 6-7'

Lth:Bore: 32-42:1

Loading: Predominantly muzzle-loading

This gun type was a smaller version of the "falcon", at least in terms of gun size. Although the majority of weapons were muzzle-loaders, some early guns of this type were breech-loading weapons, "ii halfe fawkons of ieren, with iii chambers" being mentioned (66). These small weapons were confused with serpentines during the last years of the fifteenth century, as for example they were referred to as "falconis or littel serpentines" (67). This may be an indication that early guns of this type were breech-loading swivel-mounted pieces, although early sixteenth century German illustrations of kleine falkonen depicted bronze muzzle-loading pieces (68). It is possible that the term became used to refer to a standard type of gun by the early sixteenth century, as has been suggested for the "falcon". Carr-Laughton estimated that the "falconet" of the first decade of the sixteenth century weighed approximately 100 pounds, thus being equivalent to a light swivel gun. Sheriffe's weight of 500 pounds is similar to the French fauconneau

of 1550 which weighed 410 livres. The difference in weight between Carr-Laughton's estimate and the mid-sixteenth century descriptions may be partly explained by the difference in weight between equivalent wrought-iron and cast-bronze guns, the earlier pieces then being classed with other light guns, possibly bases. Late sixteenth century Spanish medias falconetes fired a 1 to 2 pdr. shot, thus appearing similar to Sheriffe's "falconet". Guns of this type were cast in bronze, although earlier versions would have been constructed from wrought-iron, and cast-iron weapons were produced after 1543.

"Falconets" were not given a separate entry in the 1509-15 Tudor fleet inventory, so were presumably combined with "serpentines" or "falcons". Only two "falconets" were listed in the 1540 inventory, and this rarity might be a result of the re-definition of the term discussed above, and might thus only refer to cast-bronze weapons. It may have been felt that the older form of wrought-iron swivel gun provided a more cost-effective form of light gun at sea.

j). ROBINET

Bore: 1"

Shot: 0.5 pdr.

Weight: 300 lbs.

Length: 5-6'

Lth:Bore: 30-50:1

Loading: Possibly muzzle-loading.

The robinet is the smallest gun of the culverin class. The only sources providing information on this type are sixteenth century treatises, and these works give no information other than the specifications for the type. No surviving examples are known, and indeed it is not even clear if the gun was a muzzle-loader or not. The similarity in size between this weapon and contemporary arquebuses may suggest that the type could have been mounted in the manner of a land arquebus, on a forked rest, possibly fitted to a gunwale in a similar manner to a swivel-mounted gun. Weapons of a similar size were mounted in this fashion on Mediterranean vessels (69).

Port Pieces.

k). BOMBARD

Bore: 10-12"

Shot: 80-150 pdr.

Weight: over 8000 lbs.

Length: 12-20'

Lth/Bore: 6-12:1

Loading: Muzzle-loading

These weapons, dealt with earlier, continued to be used until the early sixteenth century, when these large and immobile weapons fell into disuse in western Europe. Although originally of wrought-iron construction, bronze versions were employed from the mid-fifteenth century, especially in the Ottoman empire. Such early weapons fired stone shot and could be of immense size, as existing examples demonstrate: for example Mons Meg (1469), Dulle Griet (1452) and the Dardanelles Gun (1463).

Although the average size of the "bombard" appeared to increase between 1470 and 1510, this was a reflection of a clearer definition of the term "bombard" rather than a change in the form of the weapon. Similar smaller weapons were classified as a different type. Because of this, the term "bombard" can be clearly associated with a particular type of weapon, the "large

muzzle-loading gun" described in the fifteenth century gun typology. The "bombard" was a siege weapon, immobile when set in position, and singularly difficult to transport, even though bronze weapons were frequently constructed in screw-jointed sections to allow their dismantlement after use. This gun type was produced throughout Europe, including the Ottoman Empire, although the term "lombard" occasionally used in Spanish sources in reference to the "bombard", reflected the status of Lombardy as a principal area of wrought-iron "bombard" construction (70). Although cast-bronze weapons were produced, this weapon type had become obsolete by the early sixteenth century, and cast-bronze guns of the cannon group took its place as the principal form of siege weapons.

"Bombards" were rarely used at sea because of their weight and size, and the only reference dates from 1509, when the Henry Grace a Dieu carried a "bombard" weighing 10 tons, with a bore of between 11 and 12 inches. The weapon fired a 70 pdr. stone shot, or a 200 pdr. iron shot, an interesting comparison in shot weights for the same calibre of weapon (71), illustrating the comparisons made in contemporary treatises.

1). CURTOW

Bore: 6-10"

Shot: 24-50 pdr.

Weight: 2800-5600 lbs.

Length: 8-11'

Lth/Bore: 10-16:1

Loading: Muzzle-loading

This type was characterised by its small calibre to length ratio, giving the weapon a stocky appearance similar to the earlier "bombard". English sources described the type as being divided into "great (or double) curtows" firing a 50 pdr. shot, "curtows" firing a 35 pdr. ball, and "demi-curtows", which could fire a 24 pdr. shot while German artillery inventories of 1547 list kartaunen and halbe kartaunen, firing 40 pdr. and 24 pdr. balls respectively (72). These sources thus agree on the classification of this gun type, and the German kartaunen are further described as having a bore of 17.8 centimetres, and a length of 3.4 metres, thus establishing the approximate size of weapons of this type. It is possible that "curtows" were seen as a form of bastard "bombard", fulfilling a similar role but being more mobile. It is assumed that these guns were of cast-bronze construction, as depicted in contemporary German sources (73).

The piece was first referred to as being employed at

sea in the Tudor fleet inventory of 1509-15, when a total of twelve were introduced on board the warships Sovereign and Mary Rose. Due to the weight of the pieces, it is presumed that they would be mounted near the waterline, possibly in the lower gundeck. This has been hailed as a naval armaments revolution by several naval historians, however the number of weapons in question (1.7% of the total Tudor warship armament listed in the inventory), could not have made much impact on the naval thinking of the period (74). Boeteler's Dialogues of 1634 say of curtows (curtals) that ..."in respect of their unruly reverse, they are both troublesome and dangerous; and in regard of their shortness, of little or no execution beyond the common mortar piece".

Only three other royal ships carried "curtows", and then only one piece was deployed on each ship. It may be that "curtows" were introduced on an experimental basis before 1515 and were removed after a trial period. Certainly it appears to have been unsuccessful as a ships gun as "curtows" were not listed in any later Tudor naval inventory. Similarly, "curtows" were not mentioned in the French edict of 1550, indicating that the type was already considered obsolete by the mid-sixteenth century.

m). MURDERER

Bore: 8-11"

Shot: 24-36 pdr.

Weight: 3600-6000 lbs.

Length: Unspecified

Lth:Bore: 10-15:1

Loading: Breech-loading

Although no reference can be found to the use of these pieces on land, armament inventories of the Tower of London suggest that these guns were wrought-iron breech-loading pieces, thus being similar to the "bed-mounted chambered-gun" group outlined in the fifteenth century typology.

These pieces appear to have been among the principal broadside weapons of the early Tudor Navy. "Murderers" were deployed on eleven Tudor ships in the 1509-1515 inventory, with a deployment averaging ten guns per vessel (12.5% of the total ordnance of the fleet) (75), with the largest pieces most probably carried in the Henry Grace a Dieu, whose "great murderers of iron" were of eleven inches diameter" (76).

The term "port-piece" was later used to refer to this general type of breech-loading gun, this change of nomenclature being reflected in the 1540 Tudor fleet inventory, where large wrought-iron guns were brought together under the "port-piece" group. The "port"

element may refer to gunport, and thus may mean broadside weapons.

n). SLING

Bore: 2.5"-6"
Shot: Up to 30 pdr.
Weight: Up to 2500 lbs.
Length: Up to 22'
Lth:Bore: 30:1 approx.
Loading: Breech-loading

"Slings" first appeared in the Tudor naval inventory of 1509-15, and differed from "murderers" in that the pieces were longer, with a smaller bore (77). The term "sling" covered a variety of similar weapons, classified as "double, full, three-quarter, half and quarter slings" by 1540. The smaller slings mentioned in the inventories were clearly listed in descending order of size, but "quarter slings" appear to have been classed as secondary weapons, alongside "serpentines" and "fowlers", indicating that these other categories may have been used to classify smaller breech-loading weapons according to size or weight, weapons that possibly failed to fit the parameters of any other category. By 1587, "slings" appear to have declined in

importance, becoming classed as secondary weapons although the full "sling" survived until 1628, when Norton classed it as a breech-loading gun of 2.5 inch bore firing a 2.25 to 2.5 pdr. iron or stone shot, and measuring 2.5 feet in length, thus clearly referring to a secondary weapon (78). The "sling" can therefore be seen as a weapon that declined in size and status during the sixteenth century, as the importance of wrought-iron breech-loading guns diminished.

In 1515, the Henry Grace a Dieu carried two "slings" on her lower orlop deck, with "wheels and stocks", indicating some form of gun carriage and therefore implying that they were substantial weapons. Similarly, two "slings" carried on the Great Elizabeth were, complete with their chambers, over 20 feet long (79). Because of their length, they would also require a substantial powder charge, which in turn necessitated the use of a heavy breech-chamber, of disproportionate size to the weight of shot fired. The employment of this size as broadside weapons would have created difficulties, and "slings" were recorded as having been mounted as stern chase-pieces in early sixteenth century warships (80). As such, they would have gradually become obsolete as "sakers" were introduced to this role.

Perriers.

o). STONE-SHOTTED GUNS

Bore: 5-12"

Shot: 5-64 pdr.

Weight: Up to 3000 lbs.

Length: Unspecified

Lth:Bore: 5-15:1

Loading: Either breech or muzzle-loading

Guns firing stone shot were invariably short weapons with a small length : bore ratio and due to the weakness of their shot compared with iron, they were loaded with a smaller charge. The rule of thumb was that one third of the powder used for the equivalent iron shot was used. Thus these "stone-shotted guns" were suited to the wrought-iron form of gun construction, and thus would have been relatively inexpensive. No clear division can be made between "great" stone guns, used as a part of the broadside armament of a ship and lighter "man-killing" weapons, but Carr-Laughton argues that the division should be made with guns of a 5 inch bore, and that any smaller guns should be regarded as "hailshot" weapons, of the "fowler" type (81). The economic factors which affected stone-shotted weapons were concerned with the shot itself, in that the sculpting of

stone shot was labour-intensive and required craftmanship, and thus the cost of stone shot production increased during the sixteenth century. It has been argued that this economic factor did more to encourage the widespread use of iron shot than any other consideration, since cost was the only clear advantage of iron shot (82).

This essentially medieval gun type was still in general use in 1588, employed in both the English and the Spanish fleets during the Spanish armada campaign, yet was not mentioned specifically in a maritime context before Henry VIII's fleet inventories of 1509-1515. It appears that these weapons were only employed after the "transformation in armament", which occurred in the early years of the sixteenth century. Thereafter, these weapons were employed as part of a warships main armament (83). However, stone-shotted guns were used on board galleys in the Mediterranean before this date (84). References to "stone-shotted guns" were absent from the Tudor fleet inventory of 1540, the type possibly being included under the general term "port-pieces". References to "port-pieces" in the fleet inventory of 1555 records that their bore was between 5.5 and 12 inches, indicating that "stone-shotted guns" might have been included under that heading, as no other 12 inch bore guns would still be in service (85). Bronze "stone-shotted" guns began to appear at sea by the 1540s, as is shown by the Tudor inventories. These

were the new "perrier" class of muzzle-loading weapons, a new generation of "stone-shotted gun" that would remain in use until the early seventeenth century. This more than anything else indicates the value placed upon "stone-shotted guns" during the sixteenth century. Like the earlier version of weapon, these carried a smaller chamber, up to ome-third of the width of the bore. Because of the smaller powder charge, these bronze weapons could be lightly constructed, so that their weight would not be a clear indication of their effectiveness. It is possible that part of the reason for the continued use of these weapons was that they had as yet no equal for short range destructive fire, and as such were not unlike the "carronades" of the eighteenth century.

Swivel Guns

p).SERPENTINE

Bore: 1-3"

Shot: 1-4 pdr.

Weight: 100-450 lbs.

Length: 4-7'

Lth:Bore: 30:1 approx.

Loading: Breech-loading

This was the most common gun type of the early Tudor Navy, comprising nearly 60% of the ordnance listed in the fleet inventory of 1509-1515. These were principally wrought-iron pieces, with some cast-iron pieces appearing after 1520, although not until 1543 in England (86). If the German use of the term is disregarded, where it is used as a form of general term for artillery, the "serpentine" group referred to a light gun, usually on a swivel mounting. English sources divided the type as follows:
"double serpentines", of 300 to 500 pounds in weight, and firing a 1.5 to 3 pdr. shot,
"serpentines", weighing approximately 250 pounds and firing a 1 pdr. shot, and
"small serpentines", which were scarcely larger than handguns.

Indeed, large arquebuses and hailshot pieces were sometimes called small "serpentines" and vice versa, for instance "serpentines" have been referred to as "great hackbushes, stokked" (87).

These various groups were often combined for the sake of writing an inventory, and it is often impossible to be precise as to the numbers of each gun in service on a particular vessel. Although sizes were often combined on the same vessel, this does not preclude the possibility that standard sizes were issued "en-bloc" to particular vessels, as has been suggested with the weapons made in 1513 by Cornelius Johnson of London, forty-eight of which were sent to the Katherine Forileza (88). The numbers of these weapons employed, together with their location within the vessels, indicate that they were "man-killing" guns, capable of being quickly reloaded by the replacement of a fresh chamber and shot, and were designed to sweep the enemy decks prior to and during a boarding and melee action.

By the time of Henry VIII's inventory of 1540, the term "serpentine" had disappeared. A comparison of gun types between the 1509-1515 and 1540 inventories can reveal why the term was no longer used, and what happened to the weapons involved. While "serpentines" were no longer listed two new terms had come into use, "bases" and "hailshot pieces", and the numbers involved

between "serpentines" on the one hand and the new terms on the other indicate that "serpentines" were split into these new categories, both referring to light, swivel mounted pieces (89). "Bases" were later described as small breech-loading pieces, with a weight somewhat similar to the "robinet" or "falconet", but sometimes referring to a lighter piece (therefore weighing between 100 and 300 pounds). Norton gives their maximum weight as 450 pounds, thus equivalent to "double serpentines", and so the term "double base" could be applied (90). This in turn reflects the terminology used by the Spanish, who refer to versos and verso dobles (91). "Hailshot pieces" clearly refer to the weapons earlier described as "small serpentines", and thus included weapons both with swivel mounts and guns without rests, relying on a hook to secure themselves to the gunwales or firing ports of a ship.

Thus the "serpentine" can be seen as a general term for light, secondary guns, a term which was later replaced by "base" and "hailshot piece" by 1540 at the latest.

q). FOWLERS

Bore: 1-4"

Shot: 1-4 pdr.

Weight: 100-400 lbs.

Length: 2-5'

Lth:Bore 6-8:1

Loading: Breech Loading

"Fowlers" were light "stone-shotted" weapons of small size and calibre, similar to the "serpentines" mentioned above. They have been classed under swivel guns rather than with the perrier class, as it is considered that their style of mounting was more significant than their type of shot, "fowlers" being light "man-killing" weapons similar to "serpentines". These guns were not mentioned before the 1540 inventory, and it is considered likely that they were initially grouped with the larger "stone-shotted guns", or with the "serpentines". In some inventories before 1540, light and heavy stone guns are listed as two separate but related types.

"Fowlers" (or "light stone-shotted guns") comprised 12% of the total listed Tudor naval ordnance in 1540, which meant that between three and six "fowlers" were carried on each major royal warship (92). This can be contrasted with the Jesus of Lubeck which carried ten "fowlers" in 1568. It is therefore evident that these

guns remained popular and in general use throughout the period (93). "Hailshot pieces", "small serpentines" or "quarter-slings" could also be included in this "light stone-shotted gun" category, as their armament was usually composed of small stones or flints as well as diced iron shot; however, "fowlers" are clearly distinguishable as they were specifically designed to operate with stone shot.

r). MISCELLANEOUS GUN TYPES.

This general grouping is intended to cover weapons which have not been dealt with above, and which are considered worthy of mention, in order to complete the overall survey of early sixteenth century naval armament.

Muskets.

These weapons were probably of the same type as the Italian mosquetto di bracca mentioned by Cataneo (94). These appear to have been swivel-mounted breech-loading pieces, probably of bronze, and were long, thin weapons, similar to Spanish esmerils, which, in turn, have been likened to the Venetian moschette. Smaller guns of the "musket" type may have been muzzle-loading, in a manner similar to firearms of the same name (95).

Collado gives the mosquetto a 1/8 pdr shot, thus would

be no larger than a ball from a hand held musket or arquebus. Illustrations exist depicting large muskets which may have been similar to these naval weapons (96), so lighter muskets may have been similar to these handguns, only mounted on the rails of a vessel to help absorb their recoil.

Top Pieces.

This was a term applied in the German manner, referring to means of employment rather than to gun type. "Top pieces" were guns mounted in the masts (or tops) of vessels, capable of firing onto enemy decks, presumably with an extensive use of wadding to prevent the loss of the charge when the gun was depressed (97). Tudor inventories list "light stone-shotted guns" and "serpentines" as weapons used in this manner, but all refer to small guns, with a plentiful supply of chambers (98). Conflans, amongst his description of the ideal armament for a vessel of 500 tons, includes one stone-shotted gun with twenty four chambers, and ten hackbutts (99).

Cast Pieces.

This refers to a piece of cast iron, and as this term was used in the fleet inventory of 1509-1515, it predates the establishment of the Weald iron gun foundries in 1543 (100). The casting of small iron weapons in Europe took place from the end of the

fifteenth century onwards, and these weapons most probably refer to such light weapons, of swivel gun size.

Capstan Guns.

Tudor inventories list a "stone-shotted gun" mounted on a capstan in the Katherine Fortileza, presumably designed as a weapon positioned there when there was danger of an enemy boarding attempt. The Katherine Fortileza was a Spanish built vessel, so this form of mounting may also have been common in Spain. The Mary Rose also carried a "capstan gun", with two chambers (101). As capstans were not generally placed on the weather deck in Tudor warships, this form of mounting would not have been common (102).

Vice Pieces.

The Henry Grace a Dieu is recorded as carrying four bronze "vice pieces" made by Simon Gyles of Flanders, three being long, and one a short piece (103).
Little is known about these pieces, but they were most probably experimental weapons. Carr-Laughton surmises that they may have been so called due to the use of a chase that could be unscrewed, in a manner similar to Mons Meg or other "bombards", but it may be considered more likely that the term refers to the weapon's elevating mechanism. Vice, meaning screw, was used as an unusual means of elevating some sixteenth century

weapons, as illustrated by Essenwein and Funken, and it is more likely that these would merit individual mention rather than weapons with screw-fitting breech chambers (104).

CHAPTER 2. GUN FOUNDING AND CONSTRUCTION.

Introduction.

Although gun-founding and the methods of construction used have been mentioned in the preceding chapter, these need to be reviewed in greater detail in order to complete the picture of early ordnance. Although this subject has been dealt with before, it has usually been studied on a purely national basis, or from the basis of an economic history.

This study will attempt to analyse the development of gun-founding, together with the economic and military factors that influenced it. It is also intended to review methods of gun construction in order to produce a clearer understanding of the nature of these early pieces of artillery. This will help to explain the limitations of wrought-iron pieces, resulting in their increasing obsolescence during the sixteenth century, and will attempt to understand the value placed on cast weapons, and the economic and military consequences of their production.

This chapter is arranged in three sections. The first section studies the factors that exerted an influence on gun production and outlines the general stages of the development of this production. Next, gun construction methods are examined, and notes are included on the growth of cast-iron gun-founding.

Finally, a study of the development of foundries takes the form of a catalogue of European foundries and founders.

1. The development of gun production.

a. General trends in gun founding.

The simplicity of the picture presented to us of the development of gun founding belies the problems created by the wide range of influential factors such as economics and politics. These, combined with the individuality of gun founders discussed earlier, results in a rather more complex development than is first imagined.

The earliest guns were usually built up from wrought-iron, on the hooped-construction principle outlined later in the chapter. This form of construction required little investment, and materials were relatively cheap and readily available. However, wrought-iron gun production was also manpower intensive and fell prey to the upward movement of wages in the sixteenth century (1). Guns constructed from wrought-iron remained in common use, especially at sea, until the mid-sixteenth century, by which time they were being replaced by muzzle-loading cast bronze pieces, especially in the case of larger guns.

Bronze gun production became increasingly popular from the mid-fifteenth century, but only replaced wrought-iron as the most common gun material during the early sixteenth century. The founding of bronze ordnance

required considerable investment (2), and the two metals required for its production, copper and tin, were much more expensive than iron (3).

Cast-iron muzzle loading guns made an appearance by the mid-sixteenth century. Although these were seen as technologically inferior to bronze guns, they proved popular on account of their comparatively low cost, which also helped compensate for their poorer reliability (4).

b. Factors affecting gun production.

Any study of the characteristics of gun production would be incomplete without an analysis of the economic and social factors affecting it. Economic factors, more than anything else, did much to influence gun production and, indeed, the employment of shipborne artillery.
The production of wrought-iron guns increased the demand for iron during the period, as indeed did the requirement for other military equipment, such as weapons and armour. This increase in demand was thus linked to the steady rise in the mining and production of iron ore from the mid-fifteenth century on. By 1525, European iron production was exceeding 100,000 tons per annum (5). This demand was not exclusively caused by the development of artillery, but gun production was certainly an influential factor; demand rose, not only

due to the production of the guns themselves, but also by the casting of munitions for them. The demand for gun munitions is illustrated by the fact that, at the siege of Padua (1509), between 5-10,000 iron shot were fired at the city walls, and 40,000 shot were expended during the siege of Rhodes (1522) (6).

During the late fifteenth and early sixteenth centuries, labour costs increased in relation to metal production costs, especially in Northern Europe. While these labour costs occasioned the decline in popularity of stone shot, and hence the increased popularity of iron shot, they also caused the decline of wrought-iron gun construction in favour of a less labour intensive form of production. Apart from requiring less man hours, bronze had other advantages: muzzle-loading weapons were easier to produce, guns were stronger, and they were less subject to corrosion, a factor of particular importance when guns were used at sea.

Although the two principal ingredients of bronze, copper and tin were only produced in certain areas (cf. Figure 8), casting was conducted throughout Europe. This requirement for copper ore and tin led directly to a great increase in demand from the late fifteenth century onwards. As demand increased, so did metal prices, although production costs remained stable due to the development of new mining technology during the fifteenth century. This situation made copper production a lucrative business, and from the late fifteenth

century, cartel operations by German and Italian bankers dominated the market and helped increase the dependence of the secular heads of Europe on these banking houses. The principal copper cartel operating during the sixteenth century were the Fuggers who not only controlled copper production and merchandising, but also invested money in bronze gun foundries (7). An illustration of the extent to which the Fuggers dominated the market is given in 1546, when John Owen, gun founder to Henry VIII, was forced to buy Fugger copper from warehouses in Antwerp and Brussels in order to supply the King with the artillery he required. At the time, copper held in the Fugger warehouse in Antwerp alone was valued at 1,000,000 florins (8). Bronze gun casting thus helped to increase the power of bankers, a situation that was to last throughout the "bronze age" of gun production, until the late sixteenth century. Similarly, the popularity of English cast-iron guns after 1543 was due not to any military or technological superiority, but to the relatively low cost of the weapons, compared with similar bronze guns. Indeed, the establishment of the cast iron gun foundries in the Weald was due to financial considerations, the bankrupt English crown wanted a cheaper alternative to bronze cannon founding, relying on increasingly expensive supplies of copper from the Continent (9).

Other economic factors affected gun production during the sixteenth century. Increasing supplies of

wood were required, not only for gun carriages and in the redesign of ships to carry artillery, but it was also required for the process of casting. Charcoal is produced from wood, and in 1469, 409 sacks of charcoal were used when casting a single "culverin". The weapon still continued to require wood when in action as black powder consisted of 25% charcoal. Restrictions on the felling of trees became widespread from the mid-sixteenth century, as rulers became increasingly concerned about the deforestation of their lands, caused by shipbuilding and urban growth as well as by gunfounding (10).

The cost of artillery, especially bronze weapons, was great, and represented an increasing part of any military budget during the period. Guns required a permanent force of gunners to operate them, and thus helped to establish the idea of a regular annual military budget, a basic step in the establishment of a permanent national navy. The provision of artillery for a warship such as the Mary Rose required a large outlay of capital and appeared to be a conspicuous expenditure. However, economic considerations should not be viewed in isolation. A well armed navy was a deterrent, and Royal warships were fitted out, as is the case today, in the hope that they might never be used. The reason for the outlay may thus be seen as a saving; preventing even greater expenditure in the event of a war. Also, artillery could remain in use for a long time,

especially if mounted on a merchant vessel. This is illustrated by the Spanish San Augustin, which sailed from Panama in 1606, carrying three guns, all cast before 1522 (11). Gun founders were thus limited by the lasting value of their products.

2. Gun Construction Methods.

a. Wrought Iron Gun Construction.

Wrought iron guns, also known as wrought-iron built up guns, were by far the most common gun type in terms of construction during the fifteenth century. Production of these guns continued during the early sixteenth century, but they were considered an inferior form of artillery, at least for the production of large guns. The advantages of wrought-iron over bronze as a material for gun construction were that much cheaper materials could be used, and the task required less specialised tools and equipment. The technology used to construct these weapons was that available to the average blacksmith of the period (12). Construction methods were therefore relatively simple. Iron staves were lashed around a wooden mandrel or core (cf. Figure 9), and a series of bands and hoops were passed over them while they were white hot. When cooled, they shrank onto the rods, pushing the staves together, giving a tight fit. The staves were also usually chamfered in the manner of architectural keystones, so providing a firm tubed structure. In some late examples, molten lead may have been poured between the bands, completely sealing the barrel. This technique was also employed during the repair of these weapons.

It can be seen that it was easier to construct breech-loading rather than muzzle-loading guns when applying this construction technique, as a basic tube shape presented fewer constructional and structural problems than a weapon that required the closing of the cascabel. For the same constructional reasons, the chambered pieces of wrought iron weapons were forged from cast iron, as were the chambered sections of muzzle-loading wrought-iron guns such as early bombards.

Towards the end of the fifteenth century a variation of wrought-iron construction was used, certainly in the case of swivel guns, in that the barrel was constructed from a single sheet of flattened iron, again shaped around a wooden mandrel into a barrel shape, then joined together, forming a seal. This constructional variant is known as "smooth wrought-iron construction", due to the nature of the gun surface, and is further characterised by a lack of bands and hoops when compared with wrought-iron built up guns. From the archaeological evidence, the possibility exists that this form of construction was predominant in Spain during the sixteenth century, but this theory has not yet been proved (13).

b. Cast bronze gun production.

The manufacturing of bronze guns during the period was considerably more complex than the construction of wrought-iron weapons. Contemporary techniques were described by Biringuccio in 1540 (14), followed by a number of other writers. It is intended only to give a brief outline of casting techniques here. For a more detailed account of bronze gun founding, the work by Jackson and De Beer is recommended (15).
The production of a bronze gun involved five principal stages:

i. The model stage.

A tapered wooden spindle was fitted with a capstan and placed within a wooden frame (Figure 10 top left). This was then coated with grease and closely bound with rope, forming a rope armature. This was then covered with layers of clay and smoothed into the desired shape of the gun. This model was then coated with wax to prevent the model adhering to the mould, and wax models of any inscriptions, trunnions or lifting rings were pinned in place upon its surface.

ii. The mould stage.

Layers of loam (clay and sand, mixed with water) were brushed onto the model and allowed to dry, thus building up the basis of a mould. This could then be

reinforced by more wound rope and layers of clay. The mould was then baked, the pins holding the inscriptions and trunnions were removed, and the whole mould was bound by iron hoops.The wooden spindle of the model was then removed (by simply slipping it out). The mould was then hardened by baking which melted the remaining wax of the model.

This mould was open at both ends, with the result that a cascabel mould had to be made, in a similar manner, to seal the breech end of the gun.

iii. The pit preparation stage.

The cascabel mould was placed in the casting pit the depth of which would enable the mould to be accomodated, plus an allowance for the incline from the furnace to the mould. The gun mould would then be lowered onto the cascabel mould, ensuring that a good seal was obtained. An iron core, (the dimensions of which were the same as the intended gun bore) was inserted and held in place within the mould by iron chaplets, forming an inner mould. All mould openings were then covered, and the pit packed with earth, providing a solid support for the mould.

iv. The smelting stage.

The furnace was then fired and the copper and tin inserted, under the supervision of the gun founder. Obsolete and damaged ordnance could be melted down to produce new castings. The heat would then be increased until the metal melted, providing the molten bronze required for casting.

v. The casting stage.

Channels were laid from the furnace to the mould and the molten bronze was allowed to pour along these into the mould, the flow being controlled by a furnace tap. About one day after the pour, the earth was removed and the guns hoisted out of the pit. The moulds could then be broken open, and any flash removed, along with the bell-shaped feeding head of the mould. The touchole was then bored, and boring machinery was used to ream smooth the inside of the gun.

c. Cast-iron gun production.

Iron founding had been attempted before the mid-sixteenth century but apart from the existence of early cast-iron gravestones, no evidence can be found to suggest that early iron gun casting had ever met with success. Casting techniques had been successful for smaller objects such as iron shot, but larger castings, such as guns, were brittle and prone to cracking (16).

In 1543, Henry VIII, due to virtual bankruptcy, was forced to look to local iron as a material for gun production. As a result, a group of experts was formed under parson William Levett, manager of the royal ironworks at Newbridge, Sussex. This group included Peter Baude, royal gun founder, and Ralph Hogge, iron founder, and together they produced the first successful cast-iron guns. By 1545, they were ordered to supply the King with 120 cast pieces, and,later a cast-iron siege train. Within thirty years, production exceeded 500 tons of iron castings per year, and the Sussex founders had established a name for both their skill and their products, and the sale of these weapons provided revenue for the English crown, as well as arms for her enemies (17).

Production techniques were similar to those for bronze guns, bearing in mind the different melting points of the various metals (18). The success of the

Sussex gun founders has been explained by their understanding of the basic rules of iron founding, the importance of flawless molten metal and of proper pouring methods. Also, they appear to have understood the chemical nature of iron founding, crucial for metal strength: the positive and negative roles of phosphorus and sulphur bearing ores, and the desired neutrality of cast-iron.

3. Gun Foundries and Founders.

a. Establishment.

During the fifteenth century, it was common for wrought-iron guns to be forged in rural smelters, close to the source of iron ore, it being considered cheaper to transport guns rather than unworked iron. With the increasing production of bronze guns, this situation changed as goverments considered it more important to have urban foundries where quality and export could be controlled (19). Another factor was that the copper mines required for bronze gun production were generally concentrated in central Europe, so local production was no longer possible in many cases, as was the case for wrought-iron gun manufacture.

Bronze founders who had begun their career as bell casters concentrated solely on gun production, the establishment of permanent bronze gun foundries became possible, allowing governments to make gun production more centralized. While the declining wrought-iron production centres remained in their provincial settings, bronze gun foundries were increasingly established as national foundries under state control, and national ordnance stockpiles and arsenals became common (20). Despite government control, ordnance could

still be purchased abroad in times of crisis as there appears to have been a readily accessible reserve of weapons on the market during the early sixteenth century (21).

The influence of secular rulers on the development of gun founding was significant in that many became personally interested through patronage of, and involvement with gunners and gun founders. Sovereigns such as Francis I and Henry VIII were instrumental in establishing national foundries, while the notion that the art of artillery was unworthy of the attention of the Renaissance nobility is countered by the number of renaissance monarchs who became closely involved with artillery. James II and James IV of Scotland, John II of Portugal and the German Emperor Maximillian I, all studied the art of artillery and did much not only to encourage gunfounding, but also to impress the importance of artillery on their fellow rulers (22).

b. Location.

The following description of the location of the principal European gun foundries and warehouses is intended to be no more than a general outline, designed to support the points made in Section 1 concerning geography, national control and the influence of secular rulers. For convenience, these have been divided into three groups, corresponding to modern geographical and

political areas.

i. The British Isles.

Guns were produced in and around Edinburgh Castle from 1473, and bronze weapons were cast from 1507, under the patronage of James IV. Associated founders: Borthwick, the Rowans (23).

The Tower of London produced wrought-iron guns from 1484, but it was only under the patronage of Henry VIII that in 1514, bronze foundries were established (24). Associated founders: Walker, Baude, the Owen Brothers, the Arcanas. Cast-iron gun production in Sussex has already been discussed.

ii. The Low Countries.

Lille was the centre of gun production for the dukes of Burgundy, but civil unrest forced them to withdraw their patronage, and Lille was replaced by Brugge. These foundries collapsed after the death of Charles the Bold, the last Duke of Burgundy, in 1476 (25).

The independent foundry at Liege, established by the city's prince bishop was the leading north European foundry in the fifteenth century, and continued to produce weapons until the Dutch revolt (26), with an associated foundry at Mons. Associated founder: Cambrei. Antwerp and Brussels were established as centres of production by Charles V, later to become Fugger centres

and specialising more in the sale of guns and copper than in gun casting.

Malines, the principal foundry in northern Europe during the sixteenth century, frequently sold weapons to England, France, and Scotland. Associated founder: Poppenreuyter.

iii. France.

The French monarchy did much to establish state gun foundries and arsenals, yet was vulnerable due to the country's reliance on the import of almost all the raw materials required for gun production. Charles VII established a state foundry at Tours in the late fifteenth century, and this was followed by the establishment of similar centres in Paris and Breteuil by Francis I. Associated founders: Bagot, Bouchard.

Nancy became the private arsenal of the Dukes of Lorraine during the sixteenth century, and Lyons provided the principal French market place for the purchase of foreign guns and raw materials (27).

iv. Germany.

Nuremberg, the principal metallurgical centre in Germany, was an independent centre of gun production from the mid-fourteenth century onwards, as well as the centre of German bronze gun founding during the fifteenth and early sixteenth centuries. Associated founder: Endorfer.

The Dukes of Saxony established their own gun foundry in Dresden which provided artillery for the League of German Princes during the mid-sixteenth century. By 1600, it was described as one of the most productive in Europe.

Both Augsburg (with Fugger interests), and Hamburg (with Hanseatic ones), provided a market place for the sale of ordnance during the sixteenth century.

Maximillian I established a Hapsburg foundry at Innsbruck, and by the mid-sixteenth century provided almost all the artillery required for the German Hapsburg armies, and weapons were also despatched for use by Spain (28).

v. Spain and Portugal.

John II of Portugal took an active interest in the establishment of a foundry in Lisbon, but this was inadequate to provide for the demand, created by overseas expansion. As a result, Portugal was heavily dependent on the purchase of foreign ordnance (29).

In 1495, gun foundries were established in Medina del Campo and Baza. However, after the Spanish reconquest of Malaga in 1497, the foundry at Baza was moved to Malaga, due to the fear of French invasion (30). Production at Medina del Campo declined during the early sixteenth century, but Malaga flourished, at least until after 1550. Spanish gun production was never very significant, and after 1519 it increasingly relied on German and

Italian ordnance. Associated founders: Zagala, Sumaripe.

vi. Italy.

Venice, the most famous permanent arsenal in southern Europe, cast bronze guns from the mid-fourteenth century onwards, and the state-run foundry also exported weapons during the sixteenth century. Associated founders: Alberghetti,Dei Conti.

Her foundry outstation, Brescia, produced wrought-iron guns during the fifteenth century, but was only used intermittently during the following century, as bronze production was centred in Venice. From 1537, the foundry produced and exported small cast iron weapons.

Milan was established as a gun foundry under Spanish patronage, in order to help supplement Spanish home gun production. Associated founder: Baptista.

Genoa is reported to have had a lively arms industry during the Renaissance period, and wrought-iron guns were constructed using local ore from Elba.

Finally, Bergamo developed as a trading centre for all types of armaments during the late fifteenth and early sixteenth century, as well as being a market for raw metallurgical materials.

Similarly, foundries also existed in Rome (a Papal foundry) and Florence.

Index to accompany Figure 8.

1. Edinburgh
2. Hamburg
3. London
4. Dresden
5. Brugge
6. Antwerp
7. Malines
8. Brussels
9. Liege
10. Lille
11. Breteuil
12. Paris
13. Tours
14. Nancy
15. Nuremberg
16. Augsburg
17. Lyons
18. Innsbruck
19. Milan
20. Brescia
21. Bergamo
22. Venice
23. Genoa
24. Medina del Campo
25. Lisbon
26. Malaga
27. Baza
28. The Weald

CHAPTER 3 GUN DEPLOYMENT AND EMPLOYMENT.

Introduction.

This chapter represents the crux of the study, in that the preceding two chapters serve to create a framework from which contemporary naval artillery could be examined, and its effects and military value determined. By this means, it is hoped that preconceptions regarding the nature and employment of naval artillery may be avoided. This framework will be used in connection with historical evidence to examine the deployment of artillery within ships and the design problems that resulted from this deployment. Although the development of late medieval and Renaissance vessels has been examined before, it is hoped that by the use of new information derived from underwater archaeology and by the utilisation of the framework established in preceding chapters, new theories concerning the influence of naval artillery on contemporary vessels will be obtained. Similarly, these sources will allow a detailed study to be made of gun mounting and means of employment, again based upon information from historical and archaeological sources.

This chapter is arranged in five sections. First, the deployment of shipborne artillery is examined, based upon an analysis of contemporary sources. Next, the

influence of artillery on galleys is given special consideration due to the unique nature of the vessel. This is followed by a study of gun mounting, based largely on archaeological and pictorial evidence. Then the influence of artillery on sailing ship design is reviewed, and finally, gunnery and naval tactics are examined in order to determine the effectiveness of early naval artillery.

1. The deployment of shipborne artillery.

a. Numbers and types of guns carried.

Four general phases can be traced in the evolution of shipborne artillery to 1550 which, although including areas of overlap defying a clearly defined dating system, do serve to highlight the principal stages in the transformation of naval armament that occurred during the period. The auxiliary armament phase, from the introduction of artillery until c.1450 is one where artillery, when it was deployed on ships, was very much a secondary form of missile fire, supplementing bows and crossbows. The next, light armament phase from c.1450 until c.1490, covers the period in which light guns became the principal form of missile fire, although these could be supplemented by heavier weapons. From c.1490 until c.1520, the heavy armament phase was a period which saw the increasing use of heavier ordnance and the establishment of full gundecks. The final broadside armament phase, from c.1520 to c.1550, was characterized by the increasing deployment of heavy armament, the development of a second gundeck and the establishment of the broadside-armed sailing ship. Each phase will be dealt with in detail in order to illustrate these developments.

i. The auxiliary armament phase.

Much of the evidence for this early period has been outlined in Chapter 1, including the account of the Battle off Harfleur in 1416, which describes a late medieval sea battle. The inclusion of lead, stone and iron "masses" after the list of lances and arrows clearly indicates that light guns or handguns were viewed as a supplementary form of missile weapon. This form of combat is therefore identical to that described in the account of the Battle of Sluys, fought seventy-six years previously. Melee was the principal form of combat, preceded by an exchange of missile fire. The use of artillery required no modification of current tactical practice.

The numbers of guns deployed on ships remained small throughout the auxiliary phase. The account mentioned in Chapter 1, listing royal ships of 1410, records only two to three chambered weapons per vessel. This can be compared with the armament of the English royal fleet ten years later, when out of the twenty-four sailing vessels listed, only six are recorded as carrying ordnance (1):

Holigost of the Tower: 6 guns

Thomas of the Tower: 4 guns

George of the Tower: 3 guns

Grace Dieu of the Tower: 3 guns

Katrine of the Tower: 2 guns

Andrew (Scottish Prize): 2 guns

The naval practice of the period was that merchant ships would be hired in times of emergency (2). Preconceptions concerning the role of a national navy in times of conflict cannot be applied to a study of fifteenth century maritime conflict. The notion that Henry V's ships constituted the beginnings of a standing national naval force can be dismissed. The refusal to pay for the upkeep of this force upon the death of the monarch indicate that it was viewed as the possession of the sovereign and not of the nation. This argument is reinforced by the decision to sell the king's ships to merchants in 1423 (3).

The indications are that a large pool of suitable merchant ships was available for hire during the fifteenth century, and given this style of naval combat during this period, these would prove sufficient for wartime requirements (4). The lack of an established standing fleet would also make it less likely that experiments concerning the greater employment of shipborne artillery would be carried out, so gun numbers would remain low. Therefore, the auxiliary armament

phase can be seen as one in which, although artillery was carried in ships, it was of little military value, because of the limited number and size of guns deployed, and the constraints of contemporary tactical doctrine.

ii. The light armament phase.

This phase, where light guns became the primary form of missile fire in combat, was also one in which both heavier guns appeared in ships and the vessels themselves underwent considerable changes in design. The effect of artillery on sailing ship design will be covered in Section 4.

A comparison of ship armaments during this period can indicate the trend towards the increasing reliance on shipborne artillery during the forty years of this phase. An English "kraek" of 1466 carried nine guns, one being carried "in her mast" (5). This armament, similar to that mentioned for vessels of the previous phase, may be contrasted with the armament of the English royal ship Regent, built in 1485, which carried 225 serpentines. The Sovereign, built in the same year carried 141 guns, 110 being serpentines, the remaining 31 guns being stone shotted weapons (6). This comparison indicates a substantial increase in the level of gun deployment within sailing ships during the thirty years of this phase.

Guilmartin stated that a clear-cut distinction

between merchantmen and warships did not exist in the sixteenth century and that all ships had some military potential (7).

While this applies to most sailing vessels of this period, certain royal warships such as the English Regent and the French Columbe represented a form of specialist vessel that was not designed to conduct trading voyages in times of peace, but rather acted as a naval deterrent. As such, these vessels carried a significantly larger number of guns than merchant vessels, or dual purpose royal vessels. Even if the evidence from these specialised vessels is dealt with separately, the general level of armament can be seen to increase. An inventory of English royal ships of 1485 shows the armament of four vessels, as shown below (8).

Mary of the Tower: 58 guns, 140 chambers, 12 hackbuts and 116 bows.

Grace Dieu: 21 guns (feeble), 89 chambers, 140 bows

Governer: 70 guns, 265 chambers, 51 bows, 200 gun stones

Martyn Garsia: 30 guns, 86 chambers, 4 hackbuts, 40 bows, 100 gun stones

The Grace Dieu was available for hire to London merchants in 1485 (9), so these vessels, although royal ships, may provide a more typical armament of sailing vessels during the light armament phase, and thus

underline the point made by Guilmartin that some vessels had the dual role of warship and merchantman. Indeed, Henry VII commenced a scheme of rewarding builders who produced vessels suitable for warlike purposes. The relatively small armament of the Grace Dieu is probably due to a transfer of 10 guns from the vessel, possibly to increase her cargo capacity for a planned trading voyage to the Mediterranean (10). This transfer might indicate that the crown conducted a scheme of improving the armament of merchant vessels when hired for naval service, and of removing the weapons after this service was no longer required.

The provision for bowmen on these vessels is an indication that although the number of pieces of ordnance being carried was increasing, other more traditional forms of missile fire were still a vital part of the armament of the ship, and indeed were to continue to be so until the late sixteenth century. The warship of this period evidently relied upon a system of defence which integrated light guns, melee weapons and bows, a point that will be discussed in Section 5.

The only vessel listed in the inventories of Henry VII as carrying heavier weapons was the Sovereign. In 1495, the ship carried 31 stone-shotted guns on her main deck, 20 in the waist and 11 more on the somerdeck (12). A simplified diagram depicting the deck plan of a late fifteenth or very early sixteenth century warship is found in Figure 11.

This reference to a heavy armament of "stone-shotted guns" (listed as chambered weapons, with three chambers apiece) may be indicative of a general trend towards the deployment of heavier guns, a trend not otherwise indicated by late fifteenth century royal inventories. The deployment of heavy guns in this period has often been ignored by naval historians who in the past have been content to class all late fifteenth century shipborne guns as "man-killing"; light weapons incapable of causing anything but superficial damage to an enemy. Evidence suggests that this form of heavy armament was not uncommon in 1495, and was probably in use at least ten years previously. An illustration of a vessel of about 1485, found on the Pageant of Richard Beauchamp, Earl of Warwick depicts a vessel carrying three heavy guns on one side of her waist (13). Further illustrations from the pageant depict vessels with up to four guns per side, mounted low in the waist. The mounting of heavy chambered weapons has been depicted in Mediterranean galleys of this period, as detailed in Section 2. Therefore, the appearance of similar guns in northern European vessels is not surprising.

These stone-shotted weapons are of a similar appearance to weapons found off the island of Anholt, in the Baltic (14). Two separate sites were located, both appearing to date from the late fifteenth century. The first wreck (Anholt 1) was described by its salvors in 1847 as being a vessel carrying eight wrought-iron guns

of varying size, four per side, with the heaviest pieces being deployed between the lighter ones. The second wreck (Anholt 2) was discovered in 1937, and its six wrought-iron pieces were again mounted in the waist. The ship also carried a general cargo in her hold, including a number of stowed pieces of ordnance. A study of the salvaged weapons indicates that all these pieces were heavy wrought-iron chambered pieces, with a bore of between 2.5 to 7.5 inches (6 to 18 centimetres). This evidence supports that of the Richard Beauchamp pageant illustrations, indicating that heavier guns were deployed on ships during the late fifteenth century, even on merchant vessels. Certainly the deployment of ordnance within late fifteenth century vessels appears to be more complex than is often imagined by modern historians.

iii. The heavy armament phase.

During this period, the deployment of heavy shipborne artillery greatly increased, and, in the case of major warships, the complete gundeck emerged. In order to understand this crucial evolutionary period it is necessary to examine the deployment of artillery in merchantmen and smaller vessels as well as in the major north European warships.

Dealing first with the major warships, an indication of the changes in warship armament during this heavy armament phase can be obtained by comparing the armament of the English Sovereign in 1495 and 1509 (15).

	1495	1509
Iron Guns. Serpentines:	110	42
Stone Guns:	31	9*
Slings:	-	4
Bronze Guns. Culverins:	-	3
Curtows:	-	7
Falcons:	-	6*
Total :	141	71

* : For the sake of convenience, later "murderers" have been classed with "stone-shotted guns", and the "falcon" group includes three "serpentines". The later table would also include up to six handguns, which would be

grouped in the "serpentine" category in the 1495 inventory.

This example clearly indicates the increasing number of heavy weapons deployed on warships during this phase. What is also apparent is that these new weapons introduced a new and more varied form of nomenclature, as has been outlined in Chapter 1. It can be seen that the north European warship was a specialized vessel by this period. The introduction of heavy guns in the waist and under the castles created a problem with topweight that could only be resolved if guns were placed lower in the hull, as outlined in Section 4. In a merchant vessel, the deployment of guns through ports in the overlop deck reduced cargo capacity, thus armed merchantmen and specialized warships were beginning to become separate ship types as each had different design parameters. A study of the major warships of three fleets which saw service in the war of 1512-14 may assist in the evaluation of this armament of specialized warships.

Information concerning the English fleet from 1509-15 is readily available, both from the relevant state papers and from the research of modern naval historians (16). As this information provides the most comprehensive list of shipborne armament for any early sixteenth century nation, the Tudor inventories of 1509-1515 and 1540 are listed in Appendix B, together

with a statistical analysis of their composition based upon percentages of the number of guns carried . This percentage analysis reveals a number of interesting points. The percentage of heavy guns deployed in relation to total number of guns carried showed little variance throughout the fleet, with an average of 23% . The number of "serpentines" in relation to the total number of guns carried showed a greater degree of fluctuation of between 40 and 70%, with an average throughout the fleet of 65%. Thus, in rough terms, heavy guns formed 1/4 of the total artillery complement, and "serpentines" another 2/3 of this total. As to the average size of this artillery complement, this is summarized below.

Ship size. Average number of guns

(tons)	Heavy	Light	Total
over 1000:	43	141	184
600-1000:	20	66	86
300- 599:	12	44	56

It can be argued that the English fleet represented a cross-section of the maritime state of a number of European countries, since the fleet included several vessels either bought or captured from Spain, Italy and the Hanseatic League. Whether these ships were refitted with artillery when acquired or whether their original artillery was retained is not clear, although the

Katherine Forinzela, purchased from Spain, is recorded as having a number of weapons fitted within two years of purchase (17).

The statistics concerning the early Tudor fleet are even more revealing when compared with the few major warships listed in French and Scottish inventories and accounts of the same period. Little is recorded of the armament of French warships of 1512-13. The Cordeliere of 1512 is reputed to have carried "15 gret brasyn cortawds with so marvelose nombyr of schot and other gunys of every sorte" (18). The French fleet of that year consisted of 21 warships of which 9 were owned by the crown. The fleet as a whole was described by Thomas Wolsey as being "the best with sayle and furnyshyd with artylllery and men that was ever seyn", so the level of armament may have equalled or even exceeded that of the English fleet (19). In the following year, a French warrant mentions the purchase of "deux grosses bendes d'artillerie, facons de pouldres, boulletz et autres municions", to be stockpiled for use by the fleet (20). Facons de pouldres presumably refers to swivel guns or similar light pieces. Beyond this, no more detailed list is forthcoming. An illustration of the Grande Louise (790 tons) shows a carrack carrying five guns in each side of her waist, but there is no indication of a lower gundeck. However, the depiction of the burning of the Cordeliere (700 tons) in 1512 indicates that the vessel carried at least four heavy guns on each side of a lower

gundeck (overlop deck), with other heavy ordnance sited in the waist and under the castles (21). The overlop deck was always the lowest gundeck, situated immediately above the orlop deck. Thus, despite the lack of firm documentary evidence, it can be assumed that French warships were armed in a manner similar to English warships of the same period.

The only Scottish vessel for which details of gun deployment survive from this period is James IV's flagship the Great Michael (1000 tons). Pitscottie, a later Scottish historian using undocumented sources, records that the vessel carried three basilisks (one mounted forward and two in her waist), twelve cannons (six on each side) and three hundred smaller weapons, including falcons, slings, serpentines and handguns (22). The number of heavy weapons deployed falls short of those of her English contemporary, the Henry Grace a Dieu, despite the mounting of her three basilisks. Indeed the number of heavy guns carried by this vessel, is similar to that of an English warship half her size. The Scottish Margaret (600 tons) is recorded as carrying twenty-one guns in 1506, presumably including both light and heavy pieces, so again this vessel lacked the armament of her English contemporaries (23).

From this comparison it appears that while the major north European maritime nations could afford to produce well armed and balanced fleets of specialist warships, smaller nations found the cost of this

specialization increasingly difficult. Although armed merchantmen could be hired in times of conflict, and could operate as privateers (as did the Scottish Lion in 1512), naval combat appears to have increasingly become the preserve of these major warships.

Turning from the armament of warships during the period, another source concerning the deployment of shipborne artillery on armed merchantmen during the period comes from the records and remains of the southern European vessels of discovery. The period from 1490 to 1520 saw the discovery of America and the Pacific, and the commencement of European maritime journeys to India, culminating in the first circumnavigation of the earth in 1521. In the majority of cases, these vessels were "caravels"and "naos", small merchantmen of up to 200 tons burden although towards the end of the period larger vessels were used (24). Both documentary and archaeological evidence exists for the armament of these vessels. Da Gama's flagship in 1497 carried twenty guns, and if the weapons ratio from the Tudor evidence is applied, four of these weapons would be heavy guns (25). This hypothesis is reinforced by evidence from his 1502 expedition which included caravels carrying four heavy guns, six falconets and ten swivel guns. His larger ships were armed with six heavy guns on the continuous main deck, two more on the quarterdeck, and eight "falconets" and numerous smaller swivel guns. In both cases, the larger guns and the

"falconets" were stowed below decks when not in use. This level of armament may be greater than the normal for an Iberian armed merchantmen because of the nature of the voyage. A project of investigation undertaken by the Institute of Nautical Archaeology, Texas, provides archaeological evidence for the artillery complement of these ships of discovery. Three early Caribbean wreck sites have produced ordnance, and further work is currently being undertaken in Jamaica and Haiti (26).

The Highborn Cay site, in the Bahamas, provisionally dated to the early sixteenth century, produced two heavy chambered guns and thirteen swivel guns. The location of the heavy ordnance indicated that the weapons were stowed within the ship. A similar site off the Turks and Caicos Islands, the Molasses Reef wreck, again produced two heavy chambered guns, and fifteen swivel pieces. A possible provisional date based on pottery finds is suggested as between 1508-15, although firm dating evidence has still to be aquired. The third site, still under investigation, is at Bahia Mujeres, off the Mexican coast. Again, heavy chambered guns and swivel pieces were recovered, indicating a vessel similar to the two already investigated. This complement of artillery is so similar to that described for Da Gama's caravels that it seems likely that the Carribean vessels are of the same type, and thus the programme of excavation should provide valuable information regarding the appearance of these vessels.

Another site of an Iberian vessel, at Studland Bay in England appears from an initial survey to be a Spanish merchant vessel dating from the early sixteenth century, and a comparison of ordnance finds from this site and the Carribbean ones will be of value in determining whether the ships of discovery can be taken as representative of south European armed merchant ships of the period (27).

iv. The broadside phase.

Three main factors become apparent in this phase. Bronze ordnance becomes increasingly employed, and the development of a second gundeck allowed the deployment of more heavy guns, giving the contemporary warship a potentially powerful broadside. However, as has been shown by the Mary Rose excavation, the old doctrines of naval combat were retained, and ordnance remained part of an integrated weapons system that involved artillery, archery and close combat, so that the full potential of the new broadside armament was not realised. The role of artillery as part of an integrated fighting unit, and the development of gundecks in sixteenth century warships, will be considered later in the chapter. For the moment, in order to illustrate the changes in the deployment of shipborne artillery during the period, the armament of the Mary Rose in 1509 will be compared with her armament in 1540 (28). The introduction of bronze

heavy and light guns can be illustrated by this comparison, as can the phasing out of obsolete stone-shotted guns. Lighter stone-shotted guns were reclassed as "fowlers", "serpentines" were replaced by "quarter slings" and "bases", and the old wrought-iron weapons were grouped together under the term "port pieces" (29).

The deployment of artillery on the Mary Rose

	1509	1540
Demi-cannon:	-	4
Culverin:	-	2
Demi-culverin:	-	2
Sakers:	-	5
Murderers:	6	-
Curtows:	5	-
"Stone"-guns:	26	-
Port pieces:	-	9
Slings:	2	6
Falcons:	5	2
Fowlers:	-	6
Cast Pieces:	2	-
Serpentines:	33	-
Quarter Slings:	-	60
Total :	79 guns	96 guns

Alterations in the Mary Rose armament illustrate the principal changes in the deployment of shipborne artillery during the period. However, the level to which bronze heavy ordnance was deployed in the fleet can more accurately be determined by further statistical analysis of the inventories. Details of the Tudor naval inventory for 1540 are contained in Appendix B, and again the analysis was based upon percentages of the overall artillery complement of the listed sailing warships. In

comparison with the results from the 1509 inventory, the percentage of heavy guns carried in relation to the total number of guns carried varied from 17% to 41%, with an average of 32%. The average percentage of quarter slings or bases carried averaged 49%. Thus, again in general terms, approximately 1/3 of the guns carried were heavy pieces, and 1/2 were light swivel pieces, showing a relative increase and decrease respectively, when compared to the earlier inventory. The average size of the artillery is shown below.

Ship size. Average number of guns

(tons)	Heavy	Light	Total
over 320:	21	68	89
220-320:	16	29	45
170-220:	12	32	44
100-170:	16	28	44
under 100:	22	34	56

The small size of the sample, and the lack of knowledge concerning the peculiarities of each vessel listed make valid interpretation of these figures difficult. However, the most striking aspect of these figures is that ship size bore little relation to the number of guns carried. The smallest ships in the list carry a similar number of the same type of heavy guns as the larger vessels. The smaller ships in the 1540 list carry a larger armament than vessels of a similar size listed

in the earlier inventory. For example, the Primrose of 160 tons carried the same number of heavy guns as the Katherine Fortileza of 700 tons. This can be partly explained by the increased specialisation of warships, where rather than buying and rearming merchant vessels, later ships were designed with the intention of their being fitted with artillery. The introduction of gunports increased the artillery capacity of these later warships, allowing the mounting of guns on lower decks. Also, of these heavy guns, an average of 25% were bronze on the smaller ships, the figure rising to 58% on the warships over 320 tons. F.L. Robertson argues that this introduction of bronze ordnance occurred between 1530 and 1544 (30). Certainly in 1542, the transformation in armament prompted the French ambassador to report that the English "were founding a marvellous quantity of new artillery, and that ships were being rapidly equipped" (31).

Pictorial evidence of the deployment of heavy ordnance on two decks, with lighter weapons in the upperworks, comes from the Anthony Roll, depicting the vessels of the Tudor fleet, and also in a number of contemporary paintings. The depiction of French vessels at the Battle off Portsmouth in 1546 includes two ships in the foreground, the larger with eight guns per side on her overlop deck, and the smaller ship with five. In addition to this, both vessels carry heavy guns on their weather and somer decks. By comparison, the

Henry Grace a Dieu is shown with seven guns per side mounted in her overlop deck (32). Thus it can be surmised that specialised French warships carried a similar complement of artillery to equivalent English vessels. Paintings by Bruegel the Younger and Pettyt dating from 1545-1565 clearly depict the deployment of heavy ordnance in the overlop deck and the somercastle, and the mounting of stern facing weapons on both decks (33).

The Mary Rose excavation has revealed that bronze weapons were interspersed with wrought-iron guns in the overlop deck, indicating that their placement was specific rather than random. This deployment meant that any concerted fire would have to be at close range, where the older wrought-iron guns could operate with the maximum effect (34).

Turning to the deployment of artillery in south European vessels between 1520 and 1550, an indication of the armament of Spanish vessels is found in a royal edict of 1552. An ordinance promulgated in that year listed the required ammounts of artillery, men, arms and munitions required for vessels sailing to and from the Indies (35), as follows.

	Vessel size (tons).		
	100-170	170-220	220-320
Demi-Culverins:	-	1	1
Sakers:	1	1	2
Falcons:	1	1	1
Lombards:	6	8	10
Versos:	12	18	24
Arquebuses:	12	20	30
Crossbows:	12	20	30
Gunners:	2	4	6
Powder:	9cwt.	14cwt.	18cwt.

The theoretical scheme of artillery deployment in this list can be compared with archaeological evidence from the Padre Island site, off Texas, where a number of Spanish vessels were wrecked, including a vessel most probably lost in 1554 (36). Of the artillery finds recovered from the site, only versos ("bases") and lombards ("port-pieces") were found, all wrought-iron pieces. Unless all the bronze weapons were salvaged by contemporary divers, the gun inventory is at odds with the ordnance of 1552, indicating that the actual level of armament of mid-sixteenth century Spanish vessels may have been significantly less than the level assumed by a study of contemporary written sources. Pictorial sources can again provide information on the mounting of artillery in these vessels. The Tunis tapestries depict Spanish carracks with heavy guns situated in the overlop

deck and main gundeck, with lighter guns deployed in two decks in the castles(37).

The evidence concerning the armament of Spanish vessels during this period can be compared to documents detailing the deployment of artillery in certain early sixteenth century Portuguese vessels (38) of 1515 and 1525 respectively.

Sao Miguel	Samorim
300 ton carrack)	(150 ton carrack)
14 cannons	15 cannons
4 "media espeiras"	16 falcons
2 "bombardes"	25 swivels
6 falcons	
20 swivels	

These documented armaments can be compared with those of two mid to late sixteenth century Portuguese small merchantmen. In excavations off Natal and the Seychelles the armament of two such vessels has been examined, and finds suggest the proportion of the various gun types carried may have been similar to those described above, although fewer guns were deployed on the naos (39). An additional gun type encountered in both sites were stone-shotted guns, indicating that these may also have been a weapon type in common use by the Portuguese in the mid-sixteenth century. From the close similarities between the armaments of the two wrecks, it has been suggested that the Portuguese adopted a standard system

of equipping vessels with ordnance, in a manner similar to that adopted by the Spanish in 1552.

The sum of the evidence from English, French, Spanish and Portuguese sources indicates that the deployment of heavy ordnance on sailing vessels during the broadside period followed a similar pattern throughout Europe. The emergence of two gundecks, the deployment of an increased number of heavy guns and the introduction of bronze ordnance appear to be changes that occurred irrespective of national boundaries, over a period of twenty years, from 1530 to 1550. Despite this widespread adoption of the "modern" style of artillery deployment, tactical doctrine failed to keep pace with these changes, as shown in Section 5.

2. Galleys

Although this study is primarily concerned with north-west European vessels during the period, the importance of this essentially Mediterranean ship type deserves special attention. Its use in north European waters during the sixteenth century influenced naval doctrine and actions, and thus their effect as well as their characteristics, needs to be studied.

a. Characteristics.

The effectiveness of Renaissance galleys was determined predominantly by their ability to drive through the water under the power of human muscle. Since their speed depended on low water resistance, the characteristic galley shape was long and thin, as depicted in contemporary illustrations. Galley design called for the maximum amount of space to be given over to oarsmen, and analyses of near-contemporary Venetian galley models have estimated that up to 95% of this available space was used in this manner (40). The same requirement meant that the sides of galleys were vulnerable, made up of rowers, oars and rowing frames. Since the stern was used as the command area, the only area with fighting potential within these vessels was the bow. The bow contained the missile platform (for artillery) and was the mustering point for the boarding

party. Indeed, with the exception of great galleys and galleasses, the bow was the only place where artillery could be mounted (cf. figure 12).

These characteristics, typical of the majority of Mediterranean galleys, could be modified by national differences. For example, the Spanish tended to trade weight for extra rowers (giving added momentum during a final approach), while Venetian vessels tended to rely heavily on artillery to compensate for lack of trained combatants (41). A Venetian galley was found in Lake Garda during 1967, and on examination proved to be a vessel deliberately sunk by the Venetians when their base at Lapize was threatened in 1509. The remaining part of the hull proved to be over 100 feet long, indicating an original length of approximately 120 feet. To date, no further work has been reported on this site, but a photo-mosaic survey conducted by Enrico Scandura has provided information on Venetian galley construction (42).

Apart from the Mediterranean galley, similar types of vessels were used in north-west Europe during the fifteenth and early sixteenth centuries, and there was a strong galley tradition in early Tudor England. The inventory for 1497 shows two galleys, the Sweepstake with 60 oars and the Mary Fortune of 80 oars, mounted in pairs above each other, giving a probable length of 60 feet, thus smaller than normal Mediterranean galleys. Pinnaces and Row-barges were used from 1509 onwards,

these vessels being little more than ship's boats. Row- barges have been described as weighing 20 tons, with 30 oars, thus being similar in size to Mediterranean galliots or brigantines (43). French galleys, followed the Mediterannean tradition, and indeed it is doubtful whether French galleys were permanently stationed on the Atlantic coast, or were rather called north during times of conflict with England (44).

In 1515, Henry VIII launched the Great Galley, described as being a well armed galleass, with 120 oars and a length of 180 feet. Galleasses were used by the Venetians as a term for large galleys, but the name was later clearly associated with a large oared vessel with some characteristics of conventional sailing vessels. Mediterranean style galleys in English service were given the names "subtle" or "little", to differentiate them from the royal galleasses. The galleass type was designed to combine a galley's mobility with the firepower of a carrack, but this comprimise proved a failure. The Great Galley required extensive refitting after her first year at sea, and was later converted to a vessel powered exclusively by sail, and renamed the Great Bark (45). One problem created by Tudor fleet inventories was that the term galleass was occasionally used in reference to galleys, thus causing confusion, and the researcher must observe caution when dealing with such references. Galleasses continued to be

constructed for the Tudor Navy, and the scene depicting the Battle off Portsmouth in 1545 shows two such vessels in the English fleet, and two conventional galleys (46). Indeed the inability of the English fleet to engage the French due to lack of wind during the battle may have been partly responsible for ordering of two further galleasses of 80 feet the following year (47).

Thus with the exception of these galleasses, galleys operating in northern waters were of the basic Mediterranean type, but possibly tending towards the Spanish style of galley, which gave an improved sailing ability at the expense of speed under oars. Although galleys were central to maritime conflict in the Mediterranean, the limitations imposed by climatic conditions in northern European waters meant that galleys were an expensive addition to a fleet, being confined to port in all but ideal weather conditions.

b. Armament.

The deployment of artillery in galleys during the period shows a degree of uniformity that reflects the similarities of vessel design mentioned above. The standard pattern of galley armament for all galleys from the mid-fifteenth century onwards was of a main centreline gun, the largest mounted within the vessel, with smaller guns on each side. In addition, the main armament could be interspersed with secondary swivel guns. All weapons were mounted in the bow, the swivel

guns mounted on posts either between the main guns, or on a fighting platform above them. The lack of sources mentioning a different system of gun deployment can be taken as indicating that the system described above was the normal one.

While the system of weapon placement remained standard, the weapons themselves changed, both in type and number. Artillery was mounted in galleys in the fourteenth century, as outlined in Chapter 1, but it is not until the late fifteenth century that accounts indicate the more widespread use of arillery on galleys. This date parallels the notably more numerous references to shipborne artillery in sailing vessels which has already been discussed. Spanish and Venetian galleys of the late fifteenth century are described as carrying "bombards" as their centreline armament, as indeed is an Aragonese vessel of 1506 (48). This form of "bombard" armament is depicted in a German woodcut of 1486 (49). The increasing cost of labour during the late fifteenth and early sixteenth century has already been discussed as a reason for the decline in popularity of these heavy stone-shotted weapons. "Basilisks" have also been mentioned as main guns, a Spanish flagship of 1528 carrying one along with six smaller weapons, and the French galley fleet of 1512 was also described as having been armed with Venetian "basilisks". Peter Martyr, describing these guns in 1513, said of them "one shot of those marvellous guns can sink any man of war",

which, even if an exaggeration, indicates the value placed in such weapons by contemporary mariners (50).

By the early sixteenth century, the single mounting of these large guns may be seen as unusual, while the more standard weapons package included a "cannon" or "culverin" mounted as a main centreline gun, flanked by one or more pairs of lighter weapons. "Demi-cannons", "demi-culverins", "sakers" and "periers" have all been mentioned in this context. Despite this, the level of armament could vary widely. A wreck discovered and partially surveyed off Teignmouth in Devon has produced a group of six bronze weapons, indicating that the vessel may be a galley, dating to the mid-sixteenth century (51). If, as is believed, all the main weapons have been located, the vessel's main armament consisted of a "saker", flanked by a pair of "minions". The secondary armament consisted of three large bronze swivel guns, of the petriera di bragga type. For a vessel estimated as approximately 45 metres long, this indicates a very light armament. Guilmartin considers the deployment of a light armament as a Venetian characteristic, and this tenuous Venetian link is reinforced by the fact that the saker bore the initials of a Venetian gunfounder, Sigismondo Alberghetti, one of a series of gunfounders of the same name, who worked in the period from 1539 to 1610. This group of weapon finds has now been broken up, the guns now being held by local and national museums, as well as by private owners. This

light armament can be contrasted with that of a Spanish "capitana" or flagship of 1530, which was recorded as having carried a "cannon", flanked by two "demi-culverins", three "sakers" and a "perrier". Guilmartin points out that this heavy armament was not rare in the Spanish galley fleet, but suggests that shortage of ordnance led to the underarming of other galleys as a result (52).

The galleasses of the Tudor navy were allocated an armament similar to that of a sailing ship. The Great Galley, when launched in 1515, carried seven heavy guns per side, two forward and five aft, as well as 193 secondary pieces (presumably "serpentines", "fowlers" and handguns). Seventy of the ship's guns were described as bronze by the French ambassador in his report of the launching. This arrangement of armament is similar to that of Henry VIII's galleasses of 1546, the Tiger and the Bull, which were listed in the Anthony Roll as carrying 18 and 14 main guns respectively. The gun distribution for the Bull was given as six guns on each side, with two more forward. Thus the galleass form of armament can be seen as a completely different from that of the Mediterranean galley, requiring a tactical doctrine similar if not identical to that of sailing vessels.

c. Method of operation.

Galleys were a Mediterranean phenomenon, and were not ideal vessels for northern European waters, as has already been discussed when considering the characteristics of galleys. This unsuitability was also reflected in their operational capabilities. Galleys were limited in range and endurance by the victualling of the large number of men they carried, and by the reliance upon human energy to function. The vessels were also less able to endure bad sea conditions. The lack of suitably protected anchorages compared with those in the Mediterranean limited range, and galleys venturing far from a safe base risked loss in unpredictable sea conditions, where a sailing vessel would be more likely to be able to ride out any storm. This reliance on fair weather was probably the most influential factor. Even the galeass proved unsuitable, being a hybrid vessel that failed to combine seaworthiness with increased mobility. The rebuilding of the Great Galley as a sailing vessel bears testimony to this (53).

In action, artillery armed galleys were limited by the bow-mounting of the guns, since the weapons could only be fired ahead. Speed of approach was important, and Guilmartin argues that all the artillery was fired together, immediately prior to contact. It was probable that only one shot could be fired in this situation, so this volley was important, clearing the enemy decks prior to boarding. This use of artillery is illustrated

by the account of Antonio Doria's attack on a Spanish galley in 1528, where over forty men were killed in a single volley (54). In addition to this form of attack, there is evidence for the more sustained use of artillery in combat. Attacks on a sailing ship would have to involve a greater weakening of the enemy by artillery, preferably firing from a position where the enemy would be unable to reply. This form of attack of necessity involved the ability to reload weapons and to engage the enemy in a continuous bombardment. An etching showing French galleys in action against the English fleet in 1545 depicts this type of engagement, where a bombardment of English vessels was conducted while the English sailing ships were unable to respond due to lack of wind. Algerine galleys still used this tactic of raking becalmed sailing vessels during the Napoleonic wars, so it appears to have been a standard galley tactic (55).

Above all else, galley tactics were offensive, a doctrine imposed by their design. The breaking of the English blockade of Brest by French galleys underlines this point, when six such vessels broke through the English fleet, apparently using a combination of force of momentum and gunfire. One English ship was sunk in the engagement, and another damaged in seven places, presumably by artillery fire (56). As a defensive galley tactic, Guilmartin stresses the importance of shallow water, especially when confronted with superior forces

or vessels with a deeper draught (57). In the same campaign of 1513, the six French galleys were forced to withdraw to a shallow, rocky bay. By anchoring facing the entrance, steady artillery platforms could be obtained, covering the only line of approach. In the ensuing battle, an English "cutting out" attempt was foiled, and the English admiral, Sir Edward Howard, was killed. The action illustrates the defensive as well as the offensive capabilities of the galley (58). This campaign also illustrated a number of advantages the galley had over sailing vessels. Galleys were more manoeuvrable in confined conditions, and so heavy guns could be trained without difficulty. They were also better suited to fighting a skirmish or running engagement, and, above all, they provided a more cost effective form of combat vessel in certain conditions, making better use of the weapons deployed upon them. Despite this, their failings were sufficient to discourage the widespread use of galleys outside the Mediterranean, and ultimately to explain their failure to prevent the dominance of the sailing ship in later Mediterranean naval conflicts.

3. Gun Mounting.

i. Typology.

Three principal forms of heavy gun carriages may be recognised as being in use during the period. These carriage types may be further divided by the nature of their mounting, on wheels, trucks or rails.

Type	Sub-Type
1. Sledge	Wheeled
	Trucked
	Railed
2. Frame	Wheeled
	Tracked
	Railed
3. Truck	Trucked

In order to determine any possible chronology of carriage types, and to determine the extent of their employment, these types require further definition.

ii. Definition.

1. Sledge. The gun barrel was bedded into a grooved solid wooden beam, with an upward step at the rear to help absorb the recoil. This carriage type has always been associated with wrought-iron chambered guns. A timber block was placed between the carriage step and the breech chamber in order to hold the chamber in place, and this was further secured by means of an iron or wooden V-shaped wedge. The bedded gun could then be secured to the carriage by iron straps or lashed down with rope (cf. Figure 13) (59).

This carriage could then be provided with an axle and mounted on spoked wheels or trucks (small solid wooden wheels, as found on the carriages of Napoleonic warships). There is also evidence that the carriage could be mounted on a rail, fixed to the deck of the vessel. The rear of wheeled and trucked sledge carriages could be raised and to some extent elevated by means of a wooden leg fitted through a hole at the rear of the carriage (60).

Examples of this type of carriage were associated with all the guns raised from the two Anholt wrecks in 1846-7 and 1937. Of the five surviving guns from the first site, three were secured to their carriage by iron straps, and two with rope. One of these guns (Anholt 4) was recovered complete with the remains of an axle and

wheel which later disintegrated. Of these guns, only Anholt 4 had a hole for a rear supporting leg. Of the six guns recovered in 1937, three had recesses where an axle could be fitted, and rear slots for a wooden leg, while two more were recovered with the remains of axles, but without a rear hole. A sixth smaller gun was bedded in a similar carriage, with a rear slot. A slot on the underside of the carriage was too small to be used for an axle, but was similar to fittings found on Burgundian field carriages (61). These guns were then elevated by means of a hinged board, attached to the underside of the carriage (Figure 14). Despite this modification, all the Anholt guns were mounted on similar sledge carriages (62).

During the Mary Rose excavation, four wrought-iron chambered guns were still mounted on their sledge carriages when recovered. Of these, two were mounted on a spoked wheel carriage, and two on a trucked carriage. The remains of a fifth wheeled carriage was discovered without an associated gun, which was probably recovered by an earlier salvage attempt. All these guns were mounted on the main gundeck, or in the waist (63). Carr-Laughton argued that this trucked form of carriage was ideal for stern guns, while the Anthony Roll illustrations indicate that the ports were situated nearer the deck than those for broadside guns, about one foot from the deck (64).

2. Frame. Two frames or cheeks were joined by transom pieces, forming a cradle for the gun, producing a carriage that was similar to that used by land pieces during the sixteenth century. The gun rested on these transoms, with its trunnions in recesses in the frames. This form of carriage appears to have been exclusively associated with bronze muzzle-loading weapons. Illustrations of this carriage type can be found in the works of Pietro Sardi and St. Remy (65).

Guilmartin describes this form of carriage as being the principal one in use on sixteenth century galleys. These guns were set on their trunnions, in a wooden frame, with a flat bottom. This frame then slid along a wooden rail, fixed to the bow platform of the galley. A contemporary Venetian model shows this sort of carriage fitted in a galley, and documentary evidence exists for the mounting of these railed frame carriages in French and Spanish galleys (66). A carriage was found on the Teignmouth site which appears to be of this type, and constitutes the only archaeological evidence so far obtained for this form of gun mounting (Figure 15) (67).

Wheeled frame carriages appear to have been in common use, these guns simply being field guns employed at sea (cf. Figure 16). These could be modified for sea use by shortening the gun trails and replacing the wheels with trucks. A "saker" of 1545 was described as

mounted on trestles, with its stock cut short for use at sea, and it appears that these modifications were common, at least in the early Tudor navy (68). The Spanish sea carriage appears to be little more than a modified version of the land carriage. Sir William Monson reported in 1595 that "they (the Spanish) carry their ordnance upon field carriages, which makes them the more dangerous and unserviceable" (69). An illustration of this form of carriage on a Spanish vessel of 1535 is found on the Tunis tapestries (70). From this it may be assumed that these frame carriages were in common use at sea during the early to mid-sixteenth century. Remains of large wheels and carriages recovered from the site of the Spanish Armada wreck, La Trinidad Valencera proved to be the remains of field carriages designed specifically for land use, and as such were unable to provide archaeological evidence for the use of wheeled frame carriages. However, other smaller wheel fragments were found, including solid wheels, which may suggest some form of adaption for naval use (71).

3. Truck. The four wheeled truck carriage existed as a naval gun mount without substantial modification from the early sixteenth century until after the Napoleonic wars, indicating the success of the original design, and its superiority over contemporary sea carriages. Two short wooden cheeks were fastened to a wooden baseplate,

which was in turn supported by stepped rear cheeks. Two axle trees were fitted to the baseboard, with four trucks. The front pair were usually slightly larger than the rear, in order to absorb more weight. The gun was secured and elevated around its trunnions which were fitted into recesses in the cheecks, and fastened with metal trunnion caps. This form of carriage has been exclusively associated with cast-bronze guns, and later cast-iron pieces, and represents a considerable advance of design over the earlier form of bed carriage (c.f. Figure 17) (72).

Evidence for the use of this form of carriage was again provided by the Mary Rose excavation. The remains of four truck carriages were recovered, all associated with bronze weapons. Although the same basic design was used for all these carriages, subtle differences could be detected between them, indicating that individual carriages were tailored to fit individual guns. All wooden components were found to be of elm except the axle, which was constructed of ash. Other constructional details revealed were that the side cheeks were designed to take the full weight of the gun through its trunnions, transferring the weight directly to the axles and trucks. This form of carriage was thus designed to take the weight of a heavy bronze gun, and at the same time to provide a form of mounting suitable for use in the confined space of a gundeck (73).

If the carriages were designed to fit particular guns, it appears probable that both carriage and gun were installed together. As the bronze guns were founded from 1535 on, it seems likely that these guns, with their associated carriages, were installed after the Mary Rose's refit in 1536.

Bourne, writing in 1587, stated that all English guns were mounted on truck carriages (74). Certainly, by the time of the Spanish Armada, truck carriages were fitted in royal ships, and probably also in English privateers. While it now seems evident that truck carriages were used in English vessels from 1536, at least on royal warships, it is considered less likely that other nations were so quick to adopt this form of carriage. Sir Henry Mainwaring, in 1618, wrote "the fashion of those carriages we use at sea are much better than those of the land; yet the Venetians (and Spaniards) and divers others use the other in their shipping" (75). The lack of mention of the French may be negative evidence for their adoption of truck carriages before 1587. According to Martin (1983), no evidence has been found, either in documentary sources or on the wrecks, for the use of four wheeled truck carriages aboard any of the Armada's ships, so it can be presumed that this situation also existed before 1550 (76).

iii. Limitations of carriage design.

If wheeled frame and sledge carriages were in common

use before 1550, these would have created considerable problems in gun operation and emplacement within vessels. The limitations of wheeled carriages are evident when used in the confined space of a gundeck, even if these were shortened for use at sea. The trail of a frame or sledge carriage would approximately double the length of the gun, limiting deck space. The space taken up would be increased further by the wheels, which would reduce the amount of the gun that could protrude through the gunport. If it was intended that the gun should be reloaded inboard, even more deck space would be required. Furthermore, the higher the gun was situated from the ground, the greater the tendency for it to recoil upwards as well as backwards. A possible advantage of chambered weapons could be the relative ease of reloading and that more recoil could be absorbed by the chamber and carriage, reducing this movement. Truck mounted guns, on the other hand, would allow a greater amount of the gun to protrude through the gunport, increasing working space. Monson continued his reference to the Spanish use of field pieces (wheeled frame carriages), by claiming that ".. the piece, in lying, cannot be traversed from side to side, but must be shot off directly forward as they lie" (77). This would be a reflection of the short distance the weapon could protrude through the gunport.

Evidence from the Mary Rose excavation as well as from documentary sources indicates that during this

period, recoil might have been absorbed by securing the gun and carriage to the ship's side. Bourne stated that naval guns were "fast breeched" when run out, and securing hooks were found on both the carriages recovered from the Mary Rose and from the Anholt wrecks which may have been used in this way. The limitations of this are evident, in that the force of recoil would strain the structure of the ship. During the armada campaign, the San Mateo, a Portuguese galleon, was "opened up by her own artillery", possibly as a result of stress caused by this method of recoil absorption (78). These limitations appear to indicate that gun mounting at sea was still undergoing a period of experimentation. The lack of any major fleet actions such as the Armada campaign, which could act as a "proving ground", might help to explain why a more satisfactory answer to the problems of gun mounting was not found before the end of the period.

iv. Light gun mountings.

Amost all of the light guns used on ships during the period (e.g. "serpentines", "fowlers", "bases" and possibly "falcons") employed a form of swivel mounting. Norton describes this arrangement as "a forked prop or pintle upon the ends of which the trunnions rest" (79), thus resembling the rowlock of a rowing boat. The mounting was then sunk into a hole at the base of a gunport or firing hole, or mounted on the rail of a

vessel (cf. Figure 18).

Norton also mentions a more complicated arrangement for "fowlers", where the gun was mounted on a frame, supported by trestle legs. This was then lashed to the gunport, and could be elevated by means of an elevating post, as fitted on Burgundian field guns. While the only evidence for this "fowler" mounting is provided by Norton, swivel mountings have proved to be a common find on wreck sites dating from the mid-fifteenth century until the eighteenth century. They represented an efficient form of mounting for this size of weapon, being easy to train and operate. As these guns were essentially used as "anti-personnel" weapons, these characteristics ensured the continued popularity of this form of weapon mount.

4. Artillery and Sailing Ship Design to 1550.

A detailed study of the influence of artillery upon warship design is outwith the scope of this work. Where this influence on design affected gun deployment, performance and mounting, the topic has been dealt with in the relevant sections of this chapter. Several naval historians have written about this subject, and for a more detailed consideration these works should be consulted (80). All that is intended here is to present a precis of the design of the armed sailing vessel from the time when artillery first exerted an influence upon it, placing the emphasis upon the influence of artillery as an arbiter of ship design. For this purpose it is intended to deal with the period chronologically.

i. 1350-1450.

The development of sailing ship design, although important before 1450, was hardly, if at all, influenced by artillery. Although cogs and hulks continued to be used in north European waters during this period, the vessel type which was to replace these as the principal vessel used for warfare and the carrying of large cargoes was the carrack. The origin of these vessels has been defined as Mediterranean, where northern cog designs had been adapted into the carrack design (81).

The characteristics of these ships were that they were carvel built (although vessels constructed in northern Europe retained clinker construction throughout the fifteenth century). From pictorial sources, they had a bent-back stem, and a high stern, with a length to breadth ratio of about 2.5:1 (82).

Illustrations of this type of vessel on the Amsterdam and Southampton seals of 1400-18 indicate ships with forward and after castles no longer mounted on brackets in the medieval cog style, but fitted as an integral part of the ship (83). The generally accepted theory concerning the development of carracks between 1418 and 1450 is that the after castle was extended forward, and a small somerdeck covered with a tilt-frame or awning was situated aft. This in turn was raised on stanchions, and a similar tilt-frame was placed over the forecastle, again raised on stanchions (cf. Figure 19) (84). The nature of naval warfare during this period made height an advantage, and the value of these extended and heightened platforms fore and aft must have been readily apparent. Documentary evidence suggests that an additional platform could be fitted to early fifteenth century vessels in time of war (85).

The remains of the Grace Dieu, abandoned in the Hamble River near Southampton in 1439, reveal that this great carrack was at least 125 feet long, with a beam of about 50 feet, giving a length to breadth ratio of 2.5:1, thus validating the theory proposed above. A

triple-skin 'clinker construction was used for her planking, and plank lengths were 7 feet or less (86). Reconstructions of the vessel, based upon survey work and documentary sources, reveal that the vessel was larger than the later Tudor specialized warships, with a distance from forestage deck to waterline of 52 feet (87). The number of guns carried on this vessel would still have required no modification to this design. The Grace Dieu's construction reflected the naval requirements of her day; it incorporated substantial castles in which archers and men-at-arms could be housed, yet retained the ability to carry cargo. The emplacement of a large number of guns in this already topheavy vessel would have proved extremely dangerous, and the desire to modify an already proven combination of vessel design and naval doctrine would not be forthcoming until light artillery had proved its worth in action. Modifications to this carrack design caused by shipborne artillery were therefore not forthcoming until the later fifteenth century, when the changes in gun design outlined in Chapter 1 enabled effective pieces of suitable artillery to be deployed.

ii. 1450-1500.

No archaeological evidence has yet come to light of a sailing vessel of this period that has produced enough structural remains to determine contemporary ship design. However, a large amount of pictorial evidence, supported by documentary sources has enabled naval historians to determine the evolution of ship design during the period, and to recognise the salient points of development. The principal design changes during this fifty year period centred around the extension of the carrack's upperworks, and changes brought about by the introduction of artillery.

Developments to upperworks during the period involved the extension of the poop deck and the somerdeck forward to the mainmast, the consolidation of these decks as part of the hull, and the addition of a stage and tilt-frame to the forecastle. The somerdeck still retained traces of the stanchions that supported the poop deck in the form of arched openings (cf. Figure 20). Improvements in the design of artillery encouraged its increased employment at sea, and modifications to the poop deck allowed light swivel pieces to be deployed in the arched openings of the forecastle and somercastle, as well as on the upper deck. The distribution of guns on the Sovereign in 1495 illustrates this increased ability to deploy light guns throughout the ship (cf. Figure 21). By the end of the fifteenth century the mounting of heavy guns in the

waist had led to the use of protective screens, and the cutting of ports for heavy guns enabled a greater complement of artillery to be carried without greatly compromising the stability of the vessel.

The Earl of Warwick pageant provides an excellent source of pictorial evidence for the development of the late fifteenth century carrack (88) (cf. Figure 22). At least four different vessels are depicted throughout the work, including one of a substantial carrack, and together these depictions confirm the general trends in ship design mentioned above. The large carrack has two decks in her forecastle and somercastle, with arched openings for small guns. The hull is rounded, without a significant tumble-home or rake, and is of clinker construction, as are the other vessels depicted in the work. The mounting of heavy guns in the waist is depicted on three of the vessels. One simply shows the guns mounted so as to fire over the gunwale in the waist, while the illustration of the large carrack shows similar guns protruding through the waist rail. This latter form of mounting is similar to the mounting of Spanish guns seen on the Tunis tapestries (89). Although no gunports are shown, these are shown on carracks depicted in the late fifteenth century Hastings Roll (90). It thus appears that although the general changes described above took place during the period, no clear chronological order can be established, as several methods of adaption resulting from the deployment of

artillery were in use at the same time.

It may be argued that all these modifications were first combined with the construction of the two English royal carracks, the Regent and the Sovereign, specialized warships designed with the extensive deployment of artillery in mind. The distribution of ordnance on the Sovereign indicates that the vessel had two decks in her castles, and was fitted with open gunports. If the remains of a vessel discovered at Woolwich in 1912 was correctly identified as the Sovereign, then this indicates another design feature influenced by the deployment of shipborne artillery (91). The Sovereign was launched as a clinker-built vessel, and the cutting of gunports, or indeed loading hatches in her hull, would weaken her structural integrity. The Woolwich vessel started her life as a clinker-built vessel, but was later rebuilt as a vessel of carvel construction. It can be argued that this rebuilding was to enable the vessel to carry more guns mounted in gunports, including a partial overlop deck armament. It has already been shown that the Sovereign carried a substantial number of heavy guns in 1509, after her refit.

iii. 1500-1550.

The first half of the sixteenth century saw a continuation of the process of transformation of sailing ship design, influenced by the increased use of shipborne artillery. The principal developments during this period were the addition of further decks to the two castle decks, the abandonment of clinker construction, the introduction of the tuck stern, and the development of a complete lower gundeck, with lidded gunports.

While the Warwick pageant vessels had two decks in each castle, the painting depicting Henry VIII's departure to the Cloth of Gold (1520) shows vessels with castles consisting of three and four decks (92). This is supported by other pictorial evidence, including the Anthony Roll (93). These castle decks were integral parts of the hull, creating additional space for gun arches. The upper poop deck also began to be raked. The addition of these upper levels of superstructure created problems of stability, and, to reduce topweight, these upper deck levels were of light construction. Despite this, as has been shown by the Mary Rose excavation, heavy guns could be mounted in the aftercastle. The size of these castles would have caused problems with ship handling as well as stability, possibly making these vessels heel excessively when reaching. This, combined with the low mounting of gunports on the Mary Rose may help explain the circumstances of her loss.

The introduction of a flat-tucked stern in carracks of the period may again have been a development brought about by the influence of artillery. The tuck enabled carracks to mount guns low in the stern, reducing their vulnerability to galleys in light winds, and giving them the capability to use guns in a stern chase. This coverage of a defensive "blind spot" also produced a base for an extension of the upper somerdecks, and a series of countered overhangs developed. This is clearly depicted in the "departure to the Cloth of Gold" painting, which also indicates that the introduction of the tuck-stern in the Tudor navy occured before 1509, when the first of the major warships depicted was built (94).

The abandonment of clinker construction for large vessels is again evident in pictorial sources, although vessels such as the Mary Rose and the Peter Pomegranate were initially constructed in 1509 using clinker techniques. Whether rebuilt or laid down as carvel-built vessels, the vessels of the 1546 Tudor fleet depicted in the Anthony Roll were all of carvel construction. This would result in hulls that would more readily withstand the assault of heavy artillery, and would facilitate the cutting of a line of gunports without weakening the structural integrity of the vessel.

This in turn is linked to the development of a continuous lower gundeck or overlop deck (the upper gundeck being the weather deck), and the requirement for

gunports. Descharges, a Frenchman of Brest, was credited with the invention of the lidded gunport, which allowed the increased deployment of heavy guns (95). These were placed between the longitudinal wales of the carrack, so as to reduce any weakening of the hull structure. At first these ports were fitted at the ends of the overlop deck, the midships area being avoided because of the sheer of the vessel. As the height of the overlop deck above the waterline increased, the line of ports could merge, forming a continuous second gundeck. Stability lost by this increase of vessel height was partially regained by increasing the tumble-home, thus bringing the upper deck guns nearer to the vessel's centre of gravity (96). This continuous lower gundeck was adopted by the English fleet before 1545, when the Anthony Roll was produced, and small English carracks shown in a painting of 1530 also possess a continuous line of ports (97). The illustration of the burning of the Regent and the Cordeliere (1512) depicts the French ship as having an incomplete lower gundeck, with open arched ports (98). However, both the major French carracks seen in the "Battle off Portsmouth" painting (1545), and Spanish sailing vessels illustrated in 1535, have continuous gundecks and lidded gunports (99). It thus may be considered probable that these modifications to the English fleet were completed during Henry VIII's major naval rebuilding programme, undertaken between 1522 and 1537, (a programme in which the king may have been

directly involved), and vessels of other European maritime powers developed the lower gundeck during roughly the same period.

A drawing by Holbein of a small north European merchant vessel from about 1530 depicts a vessel of carvel construction with a tuck-stern and lidded gunports (100) (cf. Figure 23.). This may be an indication that the changes brought about by artillery to sailing ship design during the period affected merchant vessels as well as specialised warships, and that design modifications were rapidly adopted by the majority of new sailing vessels. The development of the lower gundeck placed greater emphasis upon the distinction between warships and merchantmen in the sixteenth century, as the mounting of a lower gundeck would significantly reduce the cargo-carrying capacity of a merchant vessel.

Artillery was perhaps more influential upon sailing vessel design than any other single factor. Furthermore, this influence possibly resulted in more changes to its design during the early sixteenth century than during any other period, resulting in a basic configuration that was to remain unchanged until after the Battle of Trafalgar.

5. Gunnery and Naval Tactics.

Of all the aspects covered in this work this section may perhaps be the most controversial. Naval historians have proposed numerous theories regarding the way in which guns were employed, based upon very little historical evidence. Furthermore, a Victorian view of the later defeat of the Spanish Armada has led to the acceptance of erroneous assumptions concerning naval doctrine during the sixteenth century. These assumptions remained in vogue until recently refuted by a combination of archaeological and historical research (101). This increase of archaeological evidence, when combined with the historical material, provides a more secure base from which to construct any theory concerning gunnery and tactical naval doctrine during the period. This section will deal with naval gunnery, naval tactical doctrine, and the employment of vessels in action. The argument is presented in two parts, and is based upon archaeological as well as documentary evidence.

i. Naval Gunnery.

Archaeological evidence suggests that during the period it was normal for shipborne guns to be kept loaded and prepared for action when at sea (102). This would allow the use of artillery at short notice, and allow one salvo to be fired without undergoing the commotion of reloading. Shot was secured in the barrel by means of cloth wadding, and a wooden tampion could be placed in the muzzle, to protect it from dampness. Similarly, it appears common for the vent of light guns on the weather decks to be covered by a lead sheet or some similar form of protection, and it is possible that larger pieces were similarly protected from the elements. It also appears that large guns, whatever form of carriage was employed, were lashed to fastenings on the ship's side (103), in an inboard position. These lashings would therefore have to be untied if the guns were to be run out. Very little is known of gunnery before 1550, even for land weapons, but firing procedures would be similar for all heavy weapons, be they bronze or wrought-iron guns. A gunner would pour fine grained black powder into and around the vent, this acting in the manner of a fuse. The ability to train the gun would be limited by the need to secure the piece to the ship's side. As the smallest maindeck gunports on the Mary Rose were as little as seventy-five centimetres wide, the ability to train guns, or even to sight the target, would be minimal (104). Training weapons would

be less problematic with truck wheeled carriages, as these would allow more of the gun to protrude through the gunport, and the recoil would be more controlled, as indicated in section 3. Sir William Monson, referring to Spanish wheeled carriages, said ".. the piece, in lying, cannot be traversed from side to side, but must be shot off directly forward as they lie", emphasising the problems of training wheeled carriages (105). Whether or not the piece could be traversed, it was possible to elevate the weapon. In his treatise of 1587, William Bourne placed great emphasis on the sighting of the weapon by eye (106). This emphasis is contrary to his advice concerning the sighting of land artillery, where he places emphasis on a more scientific approach, using a gunner's quadrant. Bourne probably considered that the confined nature of a gundeck would inhibit the use of these more scientific methods of sighting. The gun could then be fired by applying a linstock to the vent. Bourne again emphasised the importance of firing on the roll, when the enemy vessel was rising in the swell, and on the down roll of the firing ship, to avoid a shot flying over the enemy. If this tactic was a recognised one for firing during stand-off engagements in the late sixteenth century, and the treatise was meant to be a written compilation of current gunnery practice, then this form of firing was probably practiced before 1550.

The ability to reload early naval guns whilst in action is a subject that has generally been ignored by

naval historians prior to work conducted on Spanish armada gunnery (107).

The first question to consider would be the size of gun crew available. A Napoleonic gun crew consisted of from six to twelve men, depending on gun size. While swivel guns could be fired and reloaded by one man, it is probable that the crew required to reload larger pieces in the sixteenth century would be similar to those required two hundred years later, given the similar size and weight of the pieces involved. If the crew size and composition for two Tudor vessels listed in the Anthony Roll is compared with the number of heavy guns carried, some indication of gun crew organisation emerges (108). The Henry Grace a Dieu carried 50 heavy guns, with a crew of 50 gunners, 329 soldiers and 301 mariners. The Mary Rose, with 30 heavy guns, carried 30 gunners, 185 soldiers and 200 mariners. From this, it is evident that one gunner was attached to each heavy gun. However, if full gun crews were supplied from the ranks of the mariners and soldiers, reloading and firing would involve all the remaining complement, excluding archers, and men detailed to operate the swivel guns. This is parallelled by the Spanish practice during the Armada campaign, where a gun crew consisted of a gun captain, and six soldiers (109). From this evidence it can be assumed that if more than one salvo was required, reloading would involve a significant drop in the ability of a vessel to fight in a melee. This would

appear to indicate that only one salvo was fired, presumably immediately prior to coming alongside an enemy. However, reloading during action has been recorded during the period; Vasco da Gama's fleet fought a stand-off artillery action off India in 1501, and Guilmartin stressed the ability of galleys to engage becalmed sailing ships with an artillery bombardment (110). One possible theory would be that before engaging in combat, early sixteenth century ship captains would have to decide what sort of engagement they wished to fight, and to organize their crews accordingly. The decision by Da Gama to engage in a stand-off artillery action would thus result in his inability to engage the enemy in melee, a decision influenced by his superiority in artillery, and inferiority in numbers.

The actual process of reloading would involve one of two methods. Chambered pieces would be reloaded inboard, by a relatively simple process of removing the chamber, loading the barrel with shot and wadding, and fitting a replacement chamber, with the charge already prepared. The majority of chambered guns of all sizes found on archaeological sites have been associated with at least one spare chamber. Swivel guns could be reloaded by a single operator, ensuring a rapid rate of fire. The reloading of larger pieces, such as murderers and stone-shotted guns, would require at minimum of two men to undertake the operation, with additional manpower for the heaviest weapons, such as large stone-shotted guns

and bombards. The process would be time consuming, and made more difficult if undertaken in the confined space of a lower gundeck, or on a heeling or pitching vessel.

The method of reloading muzzle-loading weapons creates more problems. Two methods could have been adopted; loading outboard or inboard. Outboard loading involved the loader climbing outboard, either out through the gunport or down from the weatherdeck, and the gun would be cleansed and loaded while the gunner sat astride the gun. This method was still practiced in 1622, when a gunner on a Danish frigate, the Christianshavn, records loading a gun by "lying outside the gunwale" (111).

Outboard loading would have been problematic on an early sixteenth century vessel, due to small gunports with protruding guns, and the fitting of weather deck anti-boarding netting when in action. This method of loading would also be more time-consuming, as only one gunner could straddle the piece at a time, as well as being highly dangerous.

If guns were loaded inboard, they would have to be unlashed from the ship's side and hauled inboard. The loaders could then operate from within the hull of the ship. Evidence from the Mary Rose excavation indicates that the muzzle-loading guns on the main gundeck could only be brought back far enough to close the gunport. Any further backwards movement was likely to be obstructed by internal features. This indicates that

internal loading could be carried out if the gunner loaded and rammed the piece with arms and torso protruding outside the gunport (112).

Both methods of reloading would place the gunners at risk from missile fire from enemy vessels if reloading was attempted when close to an enemy. These disadvantages when reloading muzzle-loading weapons must have been balanced against the greater strength and thus destructive power of bronze guns. In order to reload, a vessel would most probably have to disengage and retire to a safe distance, or alternatively turn and reload on the disengaged side. The depiction of the French galleys in action at the Battle off Portsmouth may be an example of vessels disengaging to reload. Indeed, this tactic is similar to the "carracole", a contemporary cavalry tactic, where a column of riders took turns to fire at the enemy, then retire to the rear rank to reload (113) (cf. Figure 24).

Regardless of the manner of reloading adopted, any attempt to do so in battle would necessitate a major disruption of the manpower available within the ship, and could not even be contemplated if there was risk of a boarding action.

ii. Tactical doctrine.

Until the introduction of shipborne heavy ordnance, artillery failed to influence naval tactics. The tactics employed in the few recorded naval engagements of the fifteenth century involved a combination of missile power and shock of impact. The fleet of the Earl of Devon in 1419 consisted of 5 ships and 10 balingers (or small craft).The crew for this force consisted of 926 seamen, 500 men-at-arms and 1000 archers, the proportions of men-at-arms and archers reflecting those at Agincourt, fought three years previously (114). The role of the archers would be to engage the enemy shock troops with rapid archery fire, causing disorder on the opposing vessel, then the men-at-arms could be sent in to secure the vessel. This English tactic was a direct reflection of their reliance on the longbow in combat. French vessels (including Genoese vessels in French employ), apparently contained a higher portion of shock troops, and their missile fire was supplied by crossbowmen. The losses inflicted upon the English force at the Battle of Harfleur (1416) indicate that the tactics employed at Agincourt were not necessarily ideal for combat at sea, where French crossbow fire would prove more effective (115) (cf. Figure 25). Despite this, naval tactical doctrine before the later fifteenth century evidently remained an extension of land warfare. As such, naval doctrine would only be influenced by artillery when its value had been proven on land. The

few pieces of artillery that were employed would be used in support of the archers, and to increase the disorder on the enemy upper decks. The increasing number of "serpentines" and other light guns on royal vessels during the late fifteenth century evidently reflects the gradual replacement of archers with light guns as the principal source of missile fire. This change would require no alteration of tactical doctrine as the requirement to sweep the enemy's decks prior to boarding could be achieved with both forms of missile fire. Operational considerations, if any existed, would revolve around achieving local superiority in numbers, and possibly retaining a portion of vessels as a reserve; principles that would apply as much to naval warfare in the tenth century as to fourteenth century combat.

The introduction of heavy guns to warships created a new factor that upset this old order of tactical thinking. If, as has been suggested, the use of these first stone-shotted guns was to pound the castles of the enemy vessels, creating a breach for the shock troops, then the existing doctrine could be retained, albeit in an adapted form. This pre-supposes that these weapons were designed to be fired in one salvo, immediately prior to grappling with the enemy, in the manner described for galleys during the period. Although this tactic may have been employed in a melee battle, it fails to explain why heavy chambered guns carried more

than one replacement chamber. These extra chambers indicate that the ability to reload weapons during action was considered desirable. If a salvo was fired at an enemy vessel at long range, the chances of causing damage to the ememy's upper castle decks would be slight, so this use of artillery would be restricted to close range, where there would be little possibility of firing a second shot. This form of combat would mean that the replacement chambers carried would be superfluous. At the Battle of Zonchio (1499), Ottoman heavy artillery sank a Venetian galley, but was unable to cause any notable disruption to Venetian boarders, thus implying that the weapons were fired at long range, and subsequent shots were impossible due to the closing of Venetian carracks, initiating a boarding action (116). Both this initial Ottoman fire and the carrying of spare chambers indicates that apart from initiating a boarding action, another tactical option was available.

In his action off Calibar in 1501, Vasco da Gama employed a tactic based upon stand-off artillery fire. During the action, his fleet of caravels fired repeated salvos at an Indian fleet, hitting three vessels below the waterline with the first ten shots, causing them to sink. The Portuguese continued to fight a stand-off engagement, maintaining a brisk fire with their heavy guns; "they made such haste to load again that they loaded the guns with bags of powder which they had ready for this purpose made to measure, so that they could

load again very speedily" (117). This tactic was repeated during an action off the Guinea coast in 1557, when a Portuguese squadron of five caravels used the adoption of a line ahead formation and the maintenance of the windward position to avoid boarding attempts by a pair of French and English carracks. Instead, the Portuguese engaged the enemy with artillery fire, dismasting one of their opponents before driving them away (118). This recognition of the importance of the weather gauge is further shown in the fighting instructions of Sir Thomas Audley, written in 1530. "And when the enemy doth shoot then (he shall) shoot again, and make all the smoke he can to the intent the enemy shall not see the ships, and (then) suddenly hale up his tackle aboard, and have the wind of the enemy" (119).

If these two tactical methods were available to late fifteenth and early sixteenth century naval commanders, the accepted view of the role of heavy artillery requires revision. At some point during the last two decades of the fifteenth century, the ability to engage in a stand-off engagement was realised, and thus would have profoundly influenced the choice of ordnance employed on sailing vessels. The availability of suitable artillery would exert a profound influence on the decision regarding which tactical method to adopt. It may be possible that, as the stand-off tactic was essentially a defensive one, it would be more likely to be employed by the force with a numerical inferiority,

either in vessels or manpower, or by a force with a superiority in suitable ordnance. Alonso de Chaves, in his discourse on sailing tactics written in 1530, advised that while the strongest ships should attack, grapple and board, lighter vessels should "with their artillery and munitions to harass, pursue, and give chase to the enemy" (120). Similarly, calling all contemporary actions naval engagements may be misleading, in that the sixteenth century was a period where piracy and privateering were widespread, and thus economic motives may have influenced decisions concerning tactics.

In order to maintain the ability to choose either tactic, a vessel would have to be organised and armed in such a way that she could adopt either method. It has already been suggested that once commited, this decision was irreversible and must therefore be reached before the commencement of the action, so that manpower could be allocated appropriately. Whether all the available heavy guns would be fired in either type of combat, or whether certain guns had different functions is open to question. William Bourne, in his chapter on gunnery at sea wrote "furthermore, if you do mean to enter him, then give level with your fowlers and portpieces, where you do see his chief fight of his ship is, and especially be sure to have them charged, and to shoot them off at the first boarding of the ships, for then you shall be sure to succeed". This section indicates

that muzzle-loading weapons were not used during a final salvo prior to boarding. This may be due to the location of the bronze muzzle-loading weapons on the lower gundeck, which, due to their location, would have to be fired before the ships closed for boarding. The paragraph may also be taken as a form of negative reference, indicating that a substantial part of the vessel's heavy guns were not used to influence boarding actions, but were carried for another reason, such as employment in a stand-off artillery engagement (cf. Figure 26). More research is required into this aspect of tactical doctrine, and it is hoped that post-excavation research conducted by the Mary Rose Trust will help to provide the answers. However, the established view of naval tactical doctrine prior to 1550 has evidently been over simplified, and more tactical options seem to have been available to contemporary naval commanders than has been previously supposed.

APPENDIX A

A list of examples of surviving fifteenth century ordnance

Muzzle-loading

LM	1	Basle bombard 1874-93, Mons Meg
	2	Basle - Malines bombard, Nurnburg NU 233
MM	1	Zurich 23388 Berne 10696
	2	Zurich 223381
	3	Basle 1874/94
	4	Grandson GR5, GR7 Berne 10686, Murten 116
SM	1	Berne 10697
	2	Berne 10680
	3	
	4	Basle, Neuchatel 5

Breech-loading

BC	1	Zurich K25823, La Neuville 8, Cattewater CW6
	2	Grandson GR3
SC	1	Bronze Bell 1-3,
	2	Mary Rose MR80 A1950
	3	Berne 10724
	4	Neuchatel 4

APPENDIX B : The Ordnance of the Tudor Fleet, 1509-13 and 1540.

1. 1509 - 13 Inventory

SHIP	TONS	Slings	Culverin	Curtows	Murderers	Gt Periers	Periers	Serpentines	Falcons	Cast pieces	Other guns
SOVEIGN	600	4	3	7	7	2	2	46	2		
CHRIST	300	3			8		15	26	2		
GABRIEL ROYAL	700	2	2	1	3	2	7	15	14		
GREAT BARBARA	400				10		2	19	8		
GREAT ELIZABETH	900	6			8	16	13	90			
GREAT NICHOLAS	400	2			5		1	11		2	
HENRY GRACEADIEU	1500	1	2	1	18	16	8	126	6		5
JOHN THE BAPTIST	400	2			10			34	1	1	
KATHERINE FORTILEZA	700	6		1	14		13	41	2		
MARY ROSE	500	2		5	6		26	33	5	2	
PETER POMEGRANATE	450	3			11		6	61	2		
KATHERINE GALLEY	80	2	1					6			
ROSE GALLEY	80	3			4		1	2			

2. 1540 Inventory

		BRONZE GUNS								IRON GUNS					
SHIP	TONS	Cannon	Demi-cannon	Culverins	Demi-culverins	Sakers	Falcons	Falconets	Fowlers	Port pieces	Double slings	Slings	Fowlers	Double bases	Quarter slings
LION	160					1	2			7		2	2	2	20
SWEEPSTAKE	300					5	2	1		9		2	2	8	16
JENNET	200					1	1			6	2	3	4	6	21
PRIMROSE	160				2	3	1	1		10	6		2	17	10
SMALL GALLEY	400	2	6		6	2				10	4	3		30	10
GREAT GALLEY	500	5			2	4	2			12		2		50	10
TRINITY HENRY	80		1		1	2	1			11		7	1		30
MYNYON	40		2		1	4	2			9		6	2		33
PETER	450	2	2	1		5			10	10		4	5		52
MARY ROSE	500		4	2	2	5	2			9		6	6		60

1509-15 INVENTORY

SHIP	Total Guns		Percentage of Total guns	
	Heavy	Light	Heavy	Serpentine
Henry Grace a Dieu	43	141	23	89
Gt. Elizabeth	30	103	23	90
Gabriel Royal	10	36	22	42
Katherine Fortinzela	21	56	27	73
Sovereign	20	68	23	91
Mary Rose	15	68	18	48
John Baptist	13	37	26	91
Peter Pomegranate	14	77	15	91

1540 INVENTORY

SHIP	Total Guns			Percentage of total guns		
	Heavy	Light	Total	Heavy	Bases	Bronze
Mary Rose	28	68	96	29	62	16
Peter	14	67	81	17	64	25
Sweepstake	16	29	45	36	35	18
Jennet	12	32	44	27	48	5
Lion	10	26	36	28	56	8
Primrose	21	31	52	40	19	13
Trinity Henry	22	32	54	41	53	10
Mynyon	22	37	59	37	56	15

APPENDIX C
ORDNANCE TABLES FROM SIXTEENTH CENTURY ARTILLERY TREATISES

1.fm John Sheriffe "The secrets of the (use)of Great Ordnance" (Lonodn 1560s?)

	Height of piece (inches)	Weight of piece (pounds)	Weight of shot (pounds)	Random Range (paces)
Cannon Royal	8½	7,000	66	1,930
Cannon	8	6,000	60	2,000
Cannon Serpentine	7½	5,500	53½	2,000
Bastard Cannon	7	4,500	41½	1,800
Demi Cannon	6½	4,000	30½	1,700
Cannon Pedro	6	3,000	24½	1,600
Culverin	5½	4,500	17½	2,500
Bascilisco	5	4,000	15½	-
Demi Culverin	4½	3,400	9½	2,500
Bastard Culverin	4	3,000	7	1,800
Saker	3½	1,400	5½	1,700
Minion	3¼	1,000	4	1,600
Falcon of 2¼"	2¼	800	3	1,500
Falconet	2	500	1¼	1,400
Serpentine	1½	400	½	1,300
Robinet	1	300	⅓	1,000
Falcon	¾	660	¼	1,500

2. fm William Bourne The arte of shooting in Great Ordnance (London 1587)

	Shot				
	Calibre (inches)	Diameter (inches)	Weight (pounds)	Gun length (feet)	Weight of piece (pounds)
1.Eldest double cannon	8½	8	70	12	8,000
2.Ordinary double cannon	8	7¾	64	11½-12	7,500
3.French double cannon	7¾	7½	58	11½-12	7,000
1.Demi cannon	6¾	6½	38	11-12	6,000
2.Demi cannon	6½	6¼	33	10-11	5,500
3.Demi cannon	6¼	6	20	10-11	5,000
4.French Demi cannon	6	5½	-	-	5,000
1.Narborough culverins	5½	5¾	20	12-13	4,800
2.Ordinary whole culverins	5¼	5	17	12-13	4,500
3.Culverins	5	4¾	15	12-13	4,300
1.Demi culverins(elder)	4¾	4½	12½	12	3,200
2.Demi culverins(ordinary)	4½	4½	10¼	10	2,700
3.Do(lower than ordinary)	4¼	4	8¼	9	2,200
1.Sakers	4	3¾	7	9-10	1,800
2.Sakers	3¾	3½	6	8-9	1,500
3.Sakers	3½	3¼	5-5½	8	1,300
1.Minions	3¼	3	3¼	8	1,000
2.Minions	3	2¾	3	8	-
Falcons	2¾	2½	2½	7	700
Falconets	2¼	2	1¼	-	400

NOTES.

The following abbreviations are used in the bibliography and notes:

I.J.N.A. - The International Journal of Nautical Archaeology
M.M. - Mariner's Mirror
N.R.S. - Naval Records Society
P.R.O. - Public Record Office

Chapter 1.

1. The principal contemporary sources consulted are:
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William Bourne The arte of shooting in Great Ordnance (London 1587);
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Leonhart Fronsperger Kriegsbuch (Nurnberg 1573);
Girolameo Cataneo Del' arte militare (Brescia 1571);
Luis Collado Practica Manuale di arteglieria (Venice 1586);
Robert Norton The Gunner (London 1628).

2. Fronsperger op. cit. pp. 174-175.

3. Examples of these categories are the ordnance tables of the Holy Roman Emperors Maximillian I and Charles V, quoted in
D. Miller The Landskechts (London 1976) pp. 15.

4. Vannocio Biringuccio The Pirotechnica (Venice 1540), translated by C. Smith & M. Gnudi (New York 1943) pp. 227.

5. These problems have been dealt with at length by J. S. Corbett The Spanish War 1585-1587 (London 1898) N.R.S. Appendix A pp.315-336.

6. Ibid pp. 326-336.

7. The Mongol Invasion Scroll (Japanese, c.1292) is reproduced in
S.J. Turnbull The Mongols (London 1980) pp.30.

8. This legend is outlined in
B.Rathglen Das Geshutz im Mittelalter (Berlin 1938) pp. 17-18.

9. The memorial book of the town of Ghent (Co. Bd. 1

F.8, Ghent City Archives), quoted in
A. Essenwein Quellen zur Geschichte der Feuerwaffen (Berlin 1872) pp. 282.

10. De Riformagioni di Firenzi (xxiii 65), quoted in R. C. Clephan The ordnance of the fourteenth and fifteenth centuries, in The Archaeological Journal (LXVIII) (London 1911) pp. 56.

11. B. Tierney & S. Painter Western Europe in the Middle Ages, 300-1475 (New York 1978) Third edition. pp. 536.

12. Froissart Chronicles (reprinted London 1968) Editor G. Brereton pp. 236.

13. Coltman-Clephan op. cit. pp.58.

14. Rathglen op. cit. pp. 126-128.

15. Ibid Abbildung 1-37.

16. This is reflected by the far more numerous references to torsion powered siege engines than references to artillery in Froissart op. cit.

17. Chronicles de Monstrelet (lxxviii), quoted in I. Heath Armies of the Middle Ages (London 1982) pp. 157.

18. Rathglen op. cit. pp. 132.

19. Chronicon Tarvisinum, quoted in
The proceedings of the Royal Artillery Institution (London 1902) V pp. 32.

20. Rathglen op. cit. pp.140.

21. Heath op. cit. pp. 158.

22. Ibid. pp. 160.

23. Roll TG 11097), British Library.
The date of this document was incorrectly quoted in J. Nicholas A history of the Royal Navy (London 1888) Appendix 2475.

24. W. Laird-Clowes The Royal Navy; a history (London 1897) Volume 1 pp. 102.

25. Carlton Ride Rolls, British Library, quoted in Nicholas op. cit. Appendix 2504 et seq.

26. Quoted in Coltman-Clephan op. cit. pp. 76.

27. Froissart op. cit. pp. 202.

28. Laird-Clowes op. cit. pp. 134-135.

29. See note 23.

30. Coltman-Clephan op. cit. pp. 21.

31. P.R.O. C66/399/35, quoted in J.A. Walker John Holland, a fifteenth century admiral in M.M. (London 1979) 65 pp. 235.

32. The inventories of William Soper, reproduced in S. Rose The Navy of the Lancastrian Kings (London 1982) N.R.S. pp. 61-131.

33. Ibid. pp. 28-56.

34. P.R.O. E101/55/3

35. An example of this can be found in the Catalogue of ordnance at the Museum of Artillery, Woolwich (London 1963), where unsubstantiated terminology adopted for the 1859 catalogue continues to be used.

36. Rathglen op. cit. pp. 204.

37. R. Smith & R. Brown The Royal Armouries wrought-iron cannon project (unpublished).

38. Chapter 1, Section 4 contains details of the naval use of these weapons.

39. C. ffoulkes The Gun Founders of England (Cambridge 1937) pp. 10-15.

40. A list of examples of surviving fifteenth century ordnance is contained in Appendix A.

41. J. Vigon Historia de la artilleria Espanola (Madrid 1947) Volume 1 pp. 35-36.

42. See note 40.

43. Rathglen op. cit. pp. 402.

44. B. Mader The Burgundian booty and works of Burgundian court art (Bern 1969) pp. 98-103.

45. See note 40.

46. Smith & Brown op. cit.

47. See note 40.

48. Examples of the range of mountings available for

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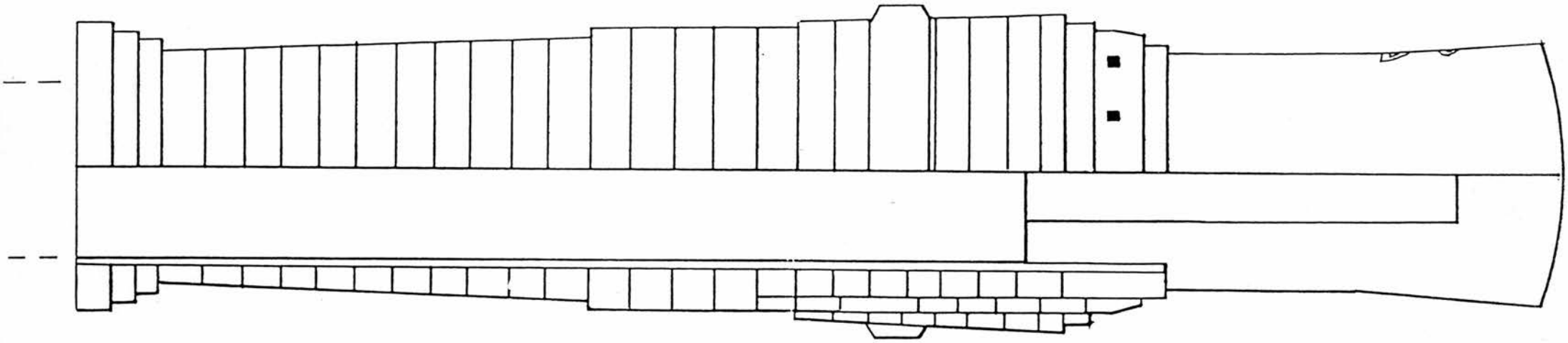

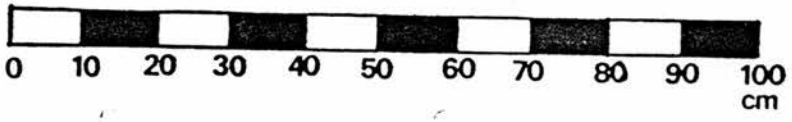
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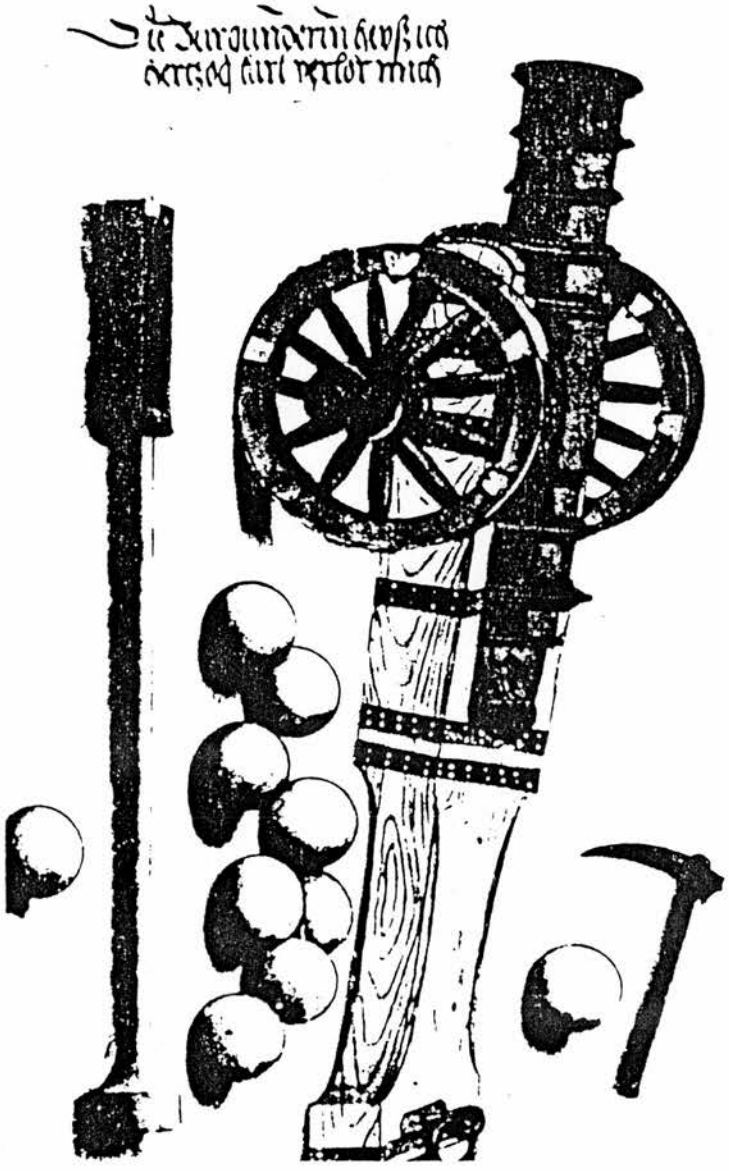
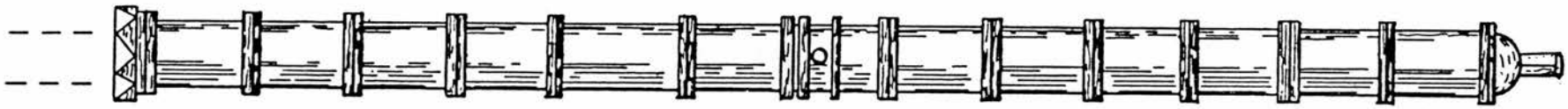
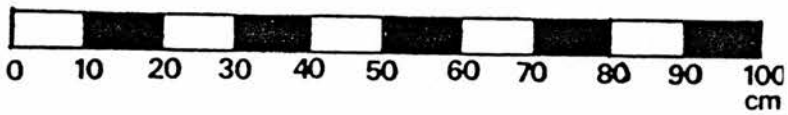
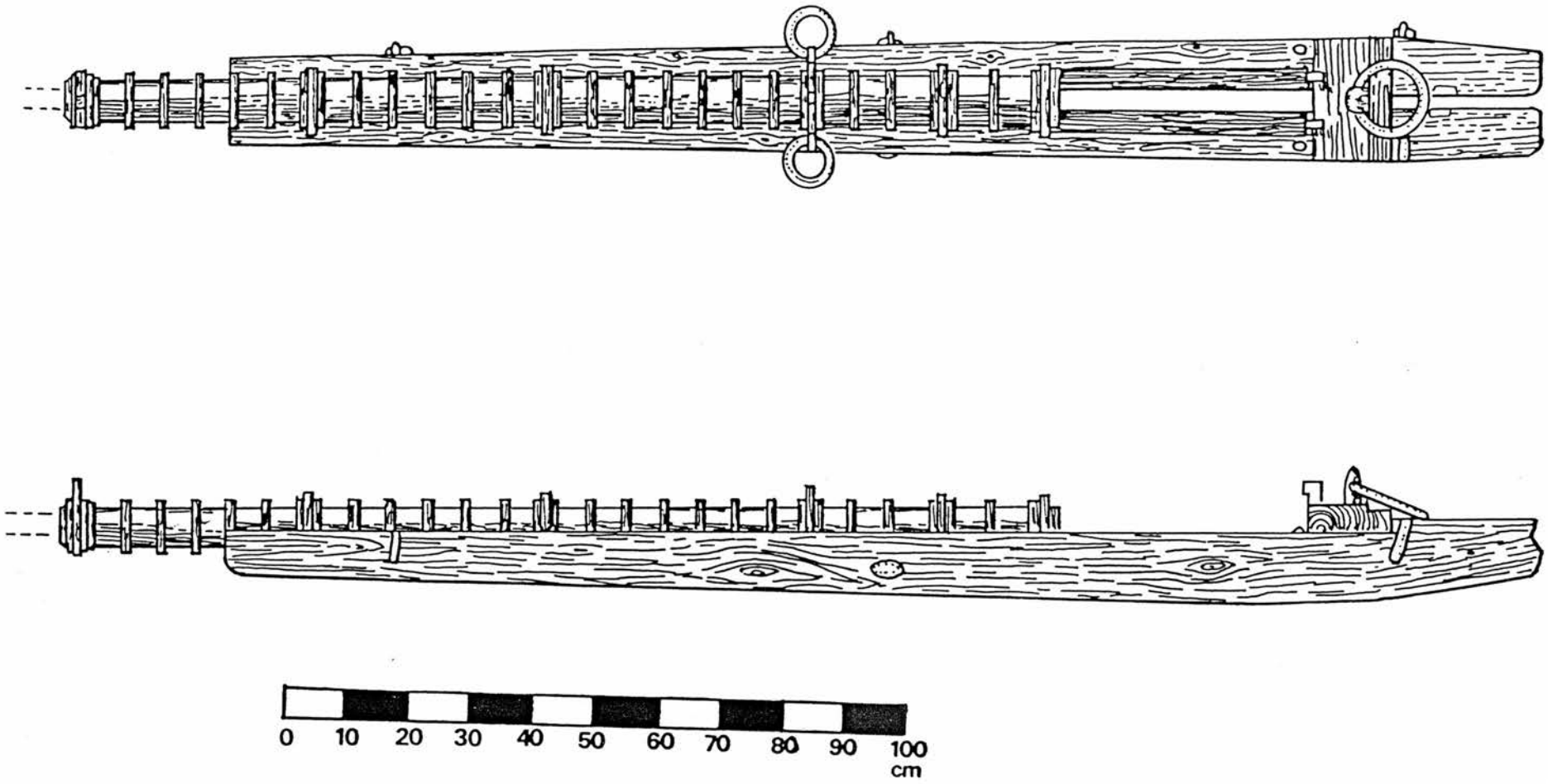
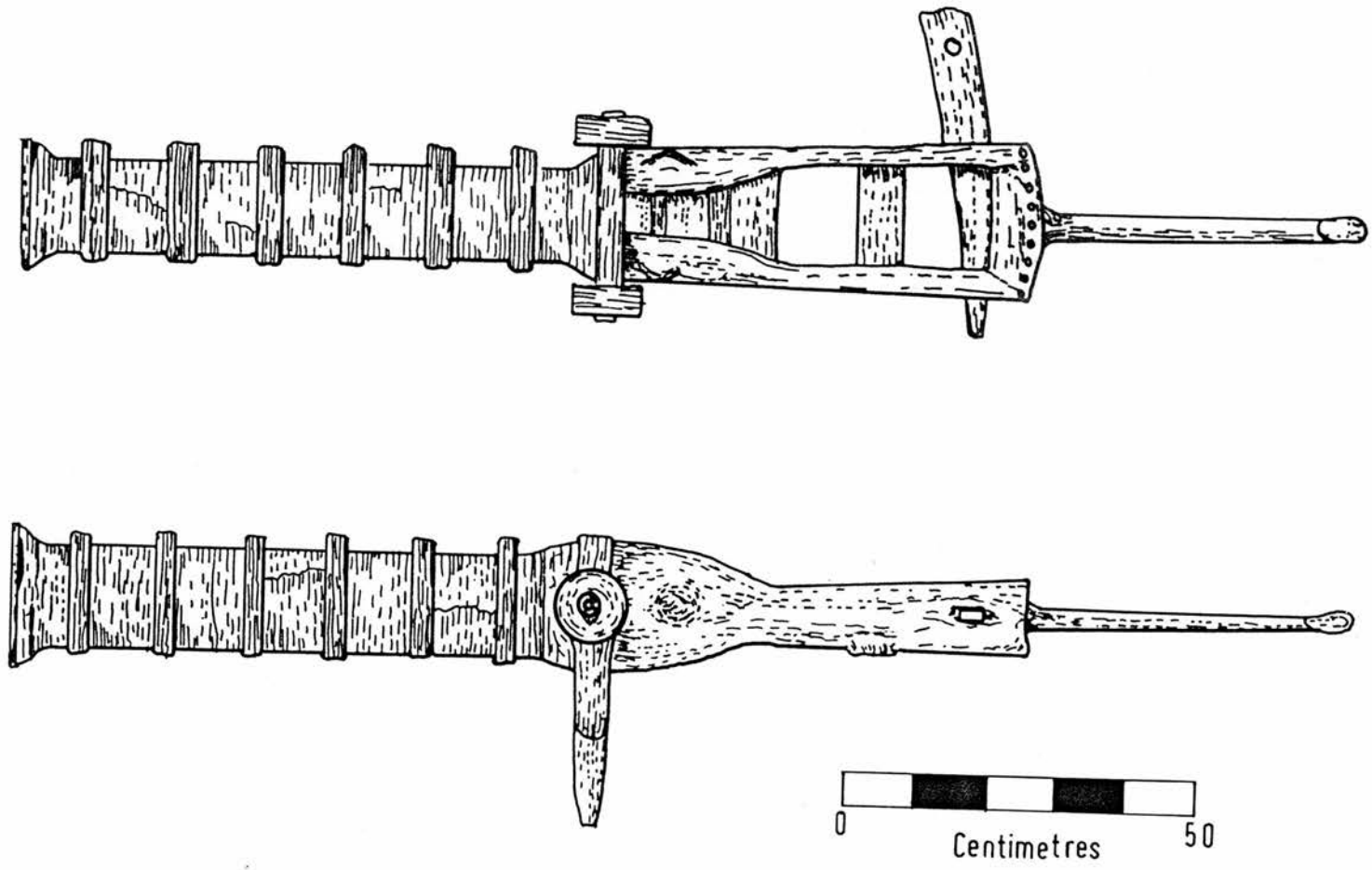
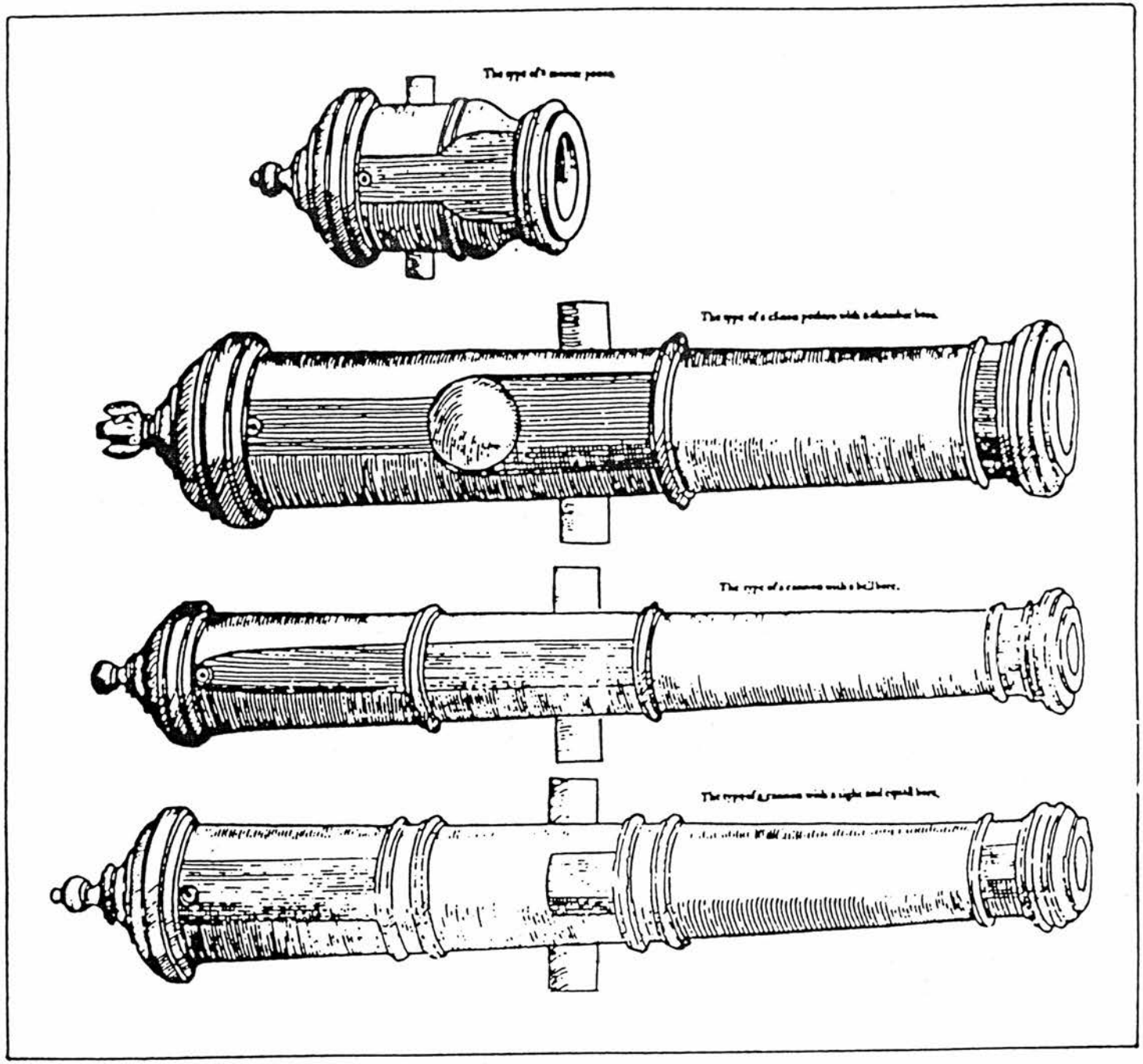


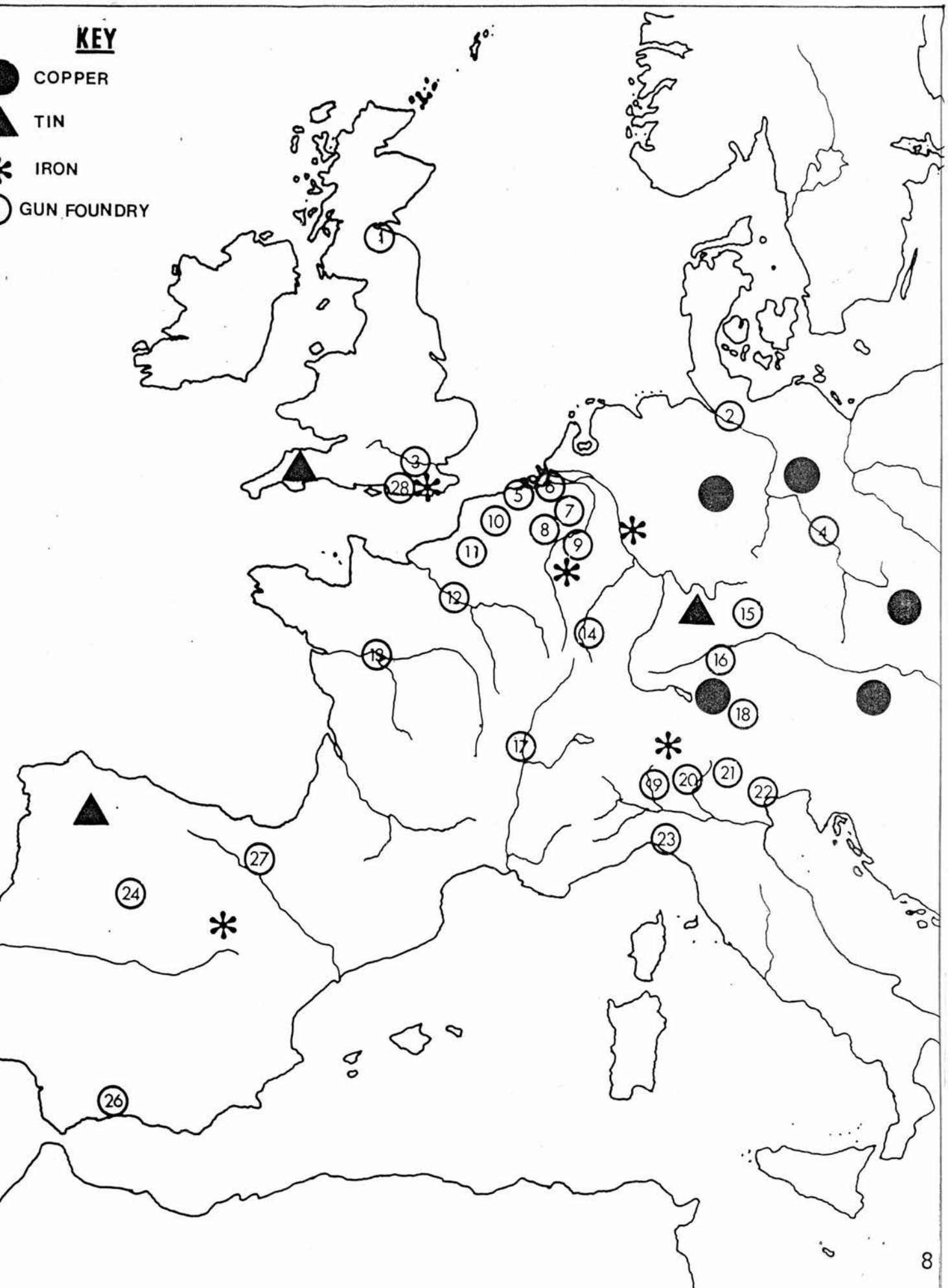


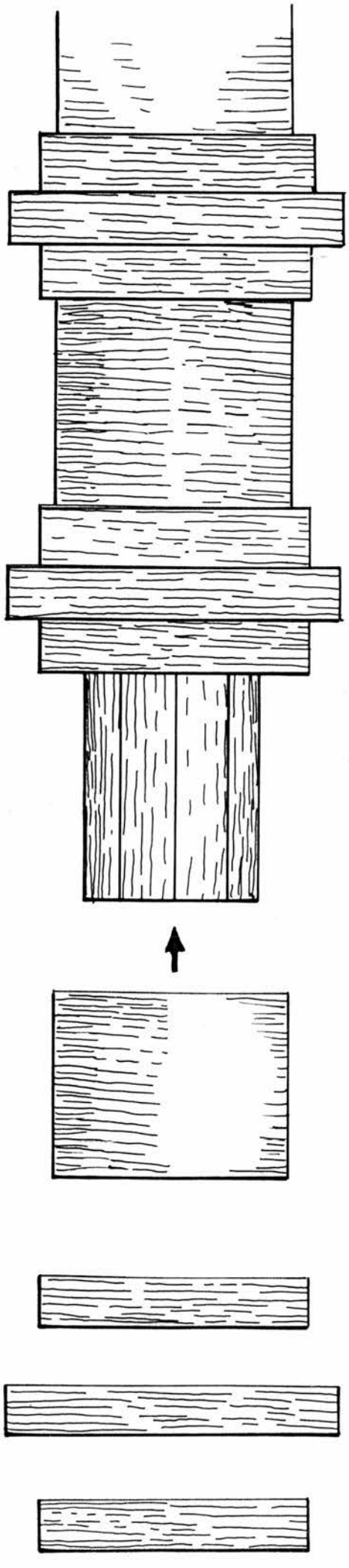

0 10 20 30 40 50 60 70 80 90 100
cm

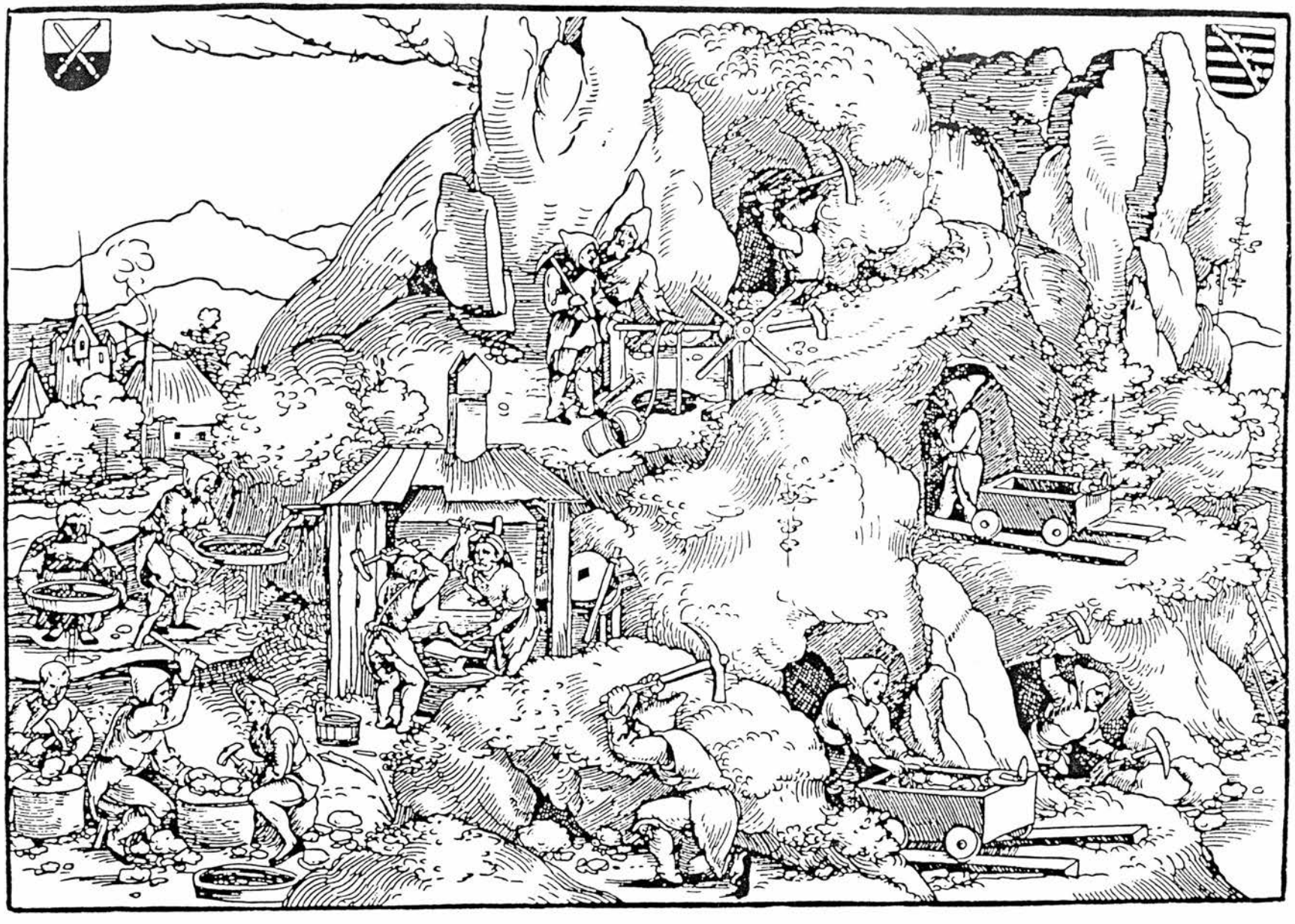

0 10 20 30 40 50 60 70 80 90 100
cm

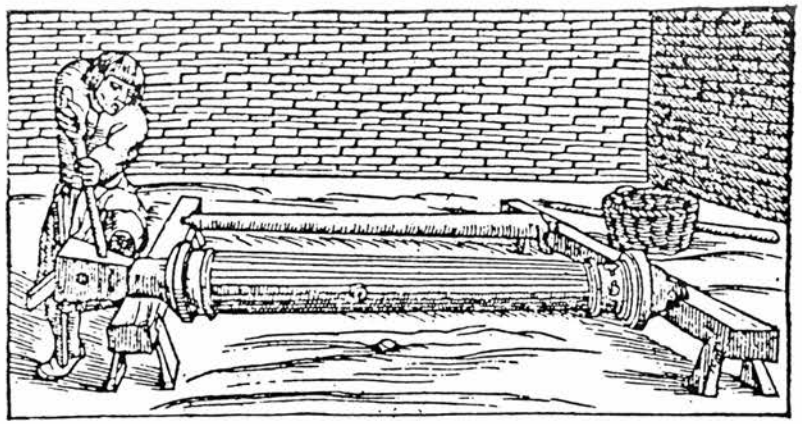

0
Centimetres
50

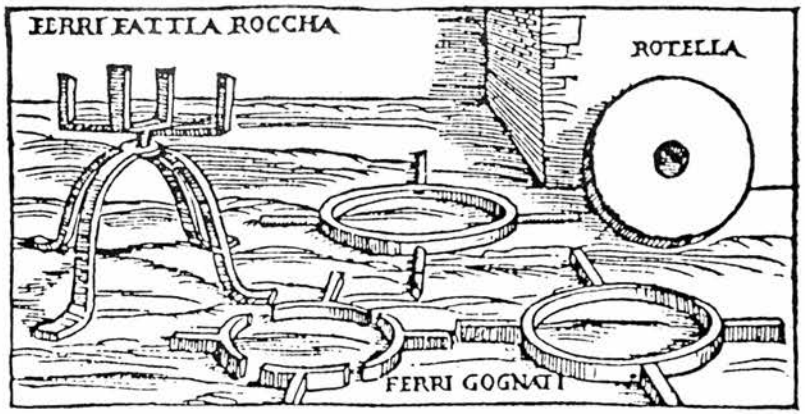


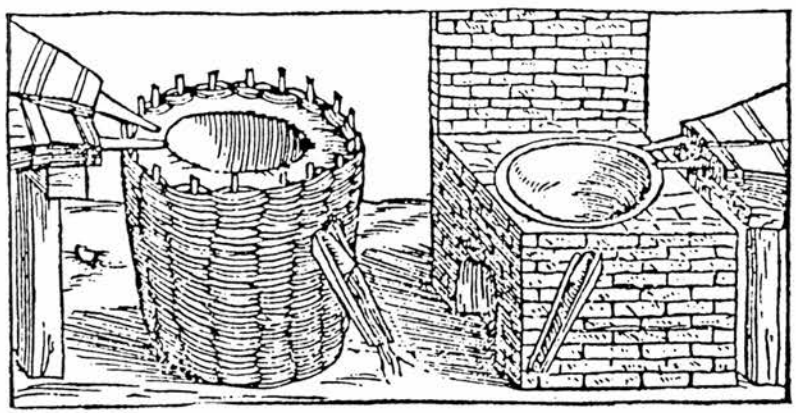

KEY
COPPER
TIN
IRON
GUN FOUNDRY
1
2
3
28
5
6
7
8
9
10
11
12
13
14
15
16
18
17
19
20
21
22
23
24
27
26
4

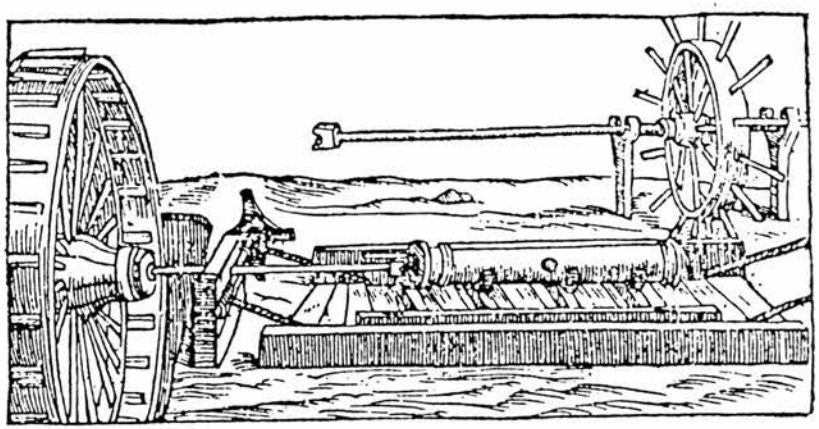


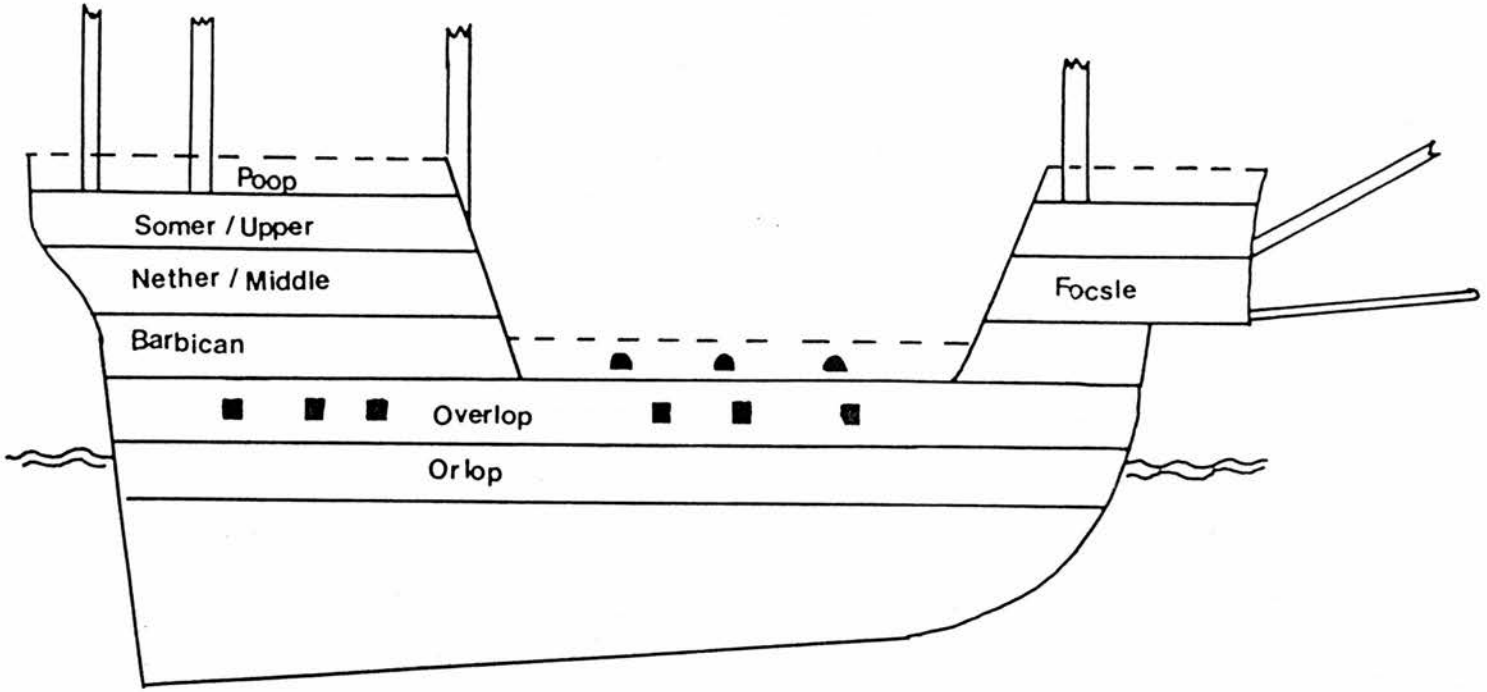


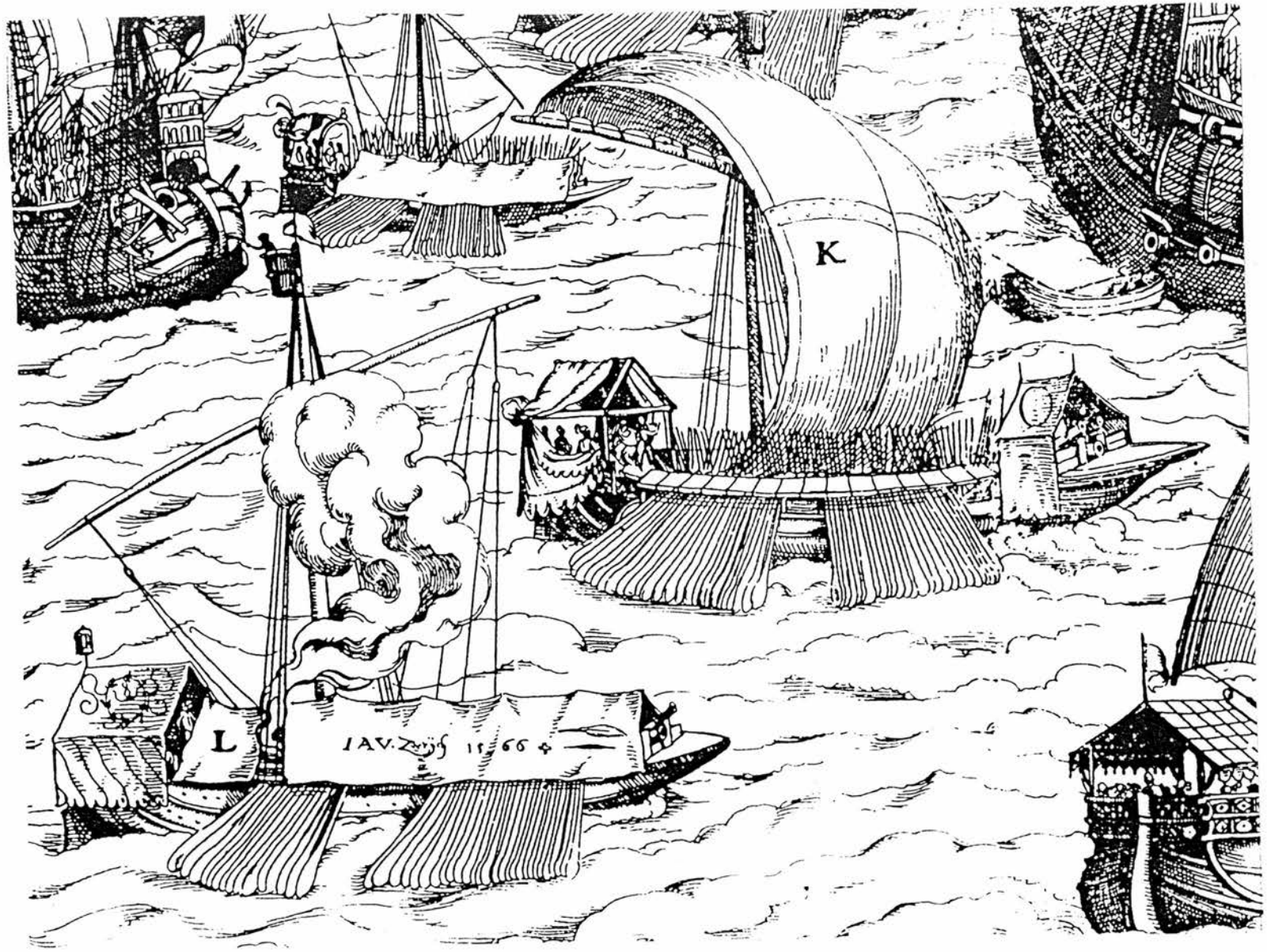


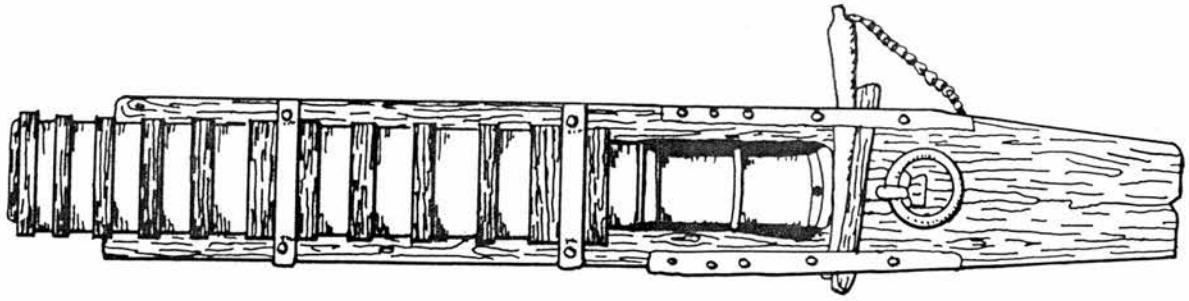

FERRI FATTI A ROCCHA
ROTELLA
FERRI GOGNATI



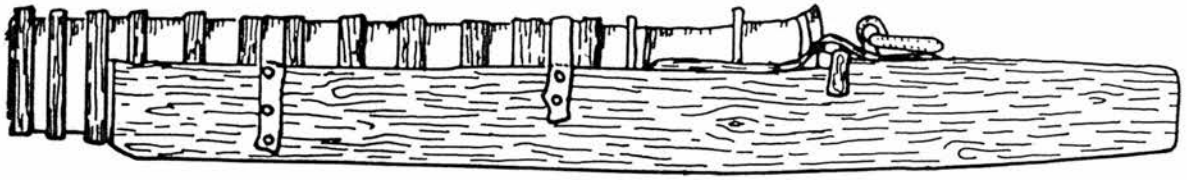


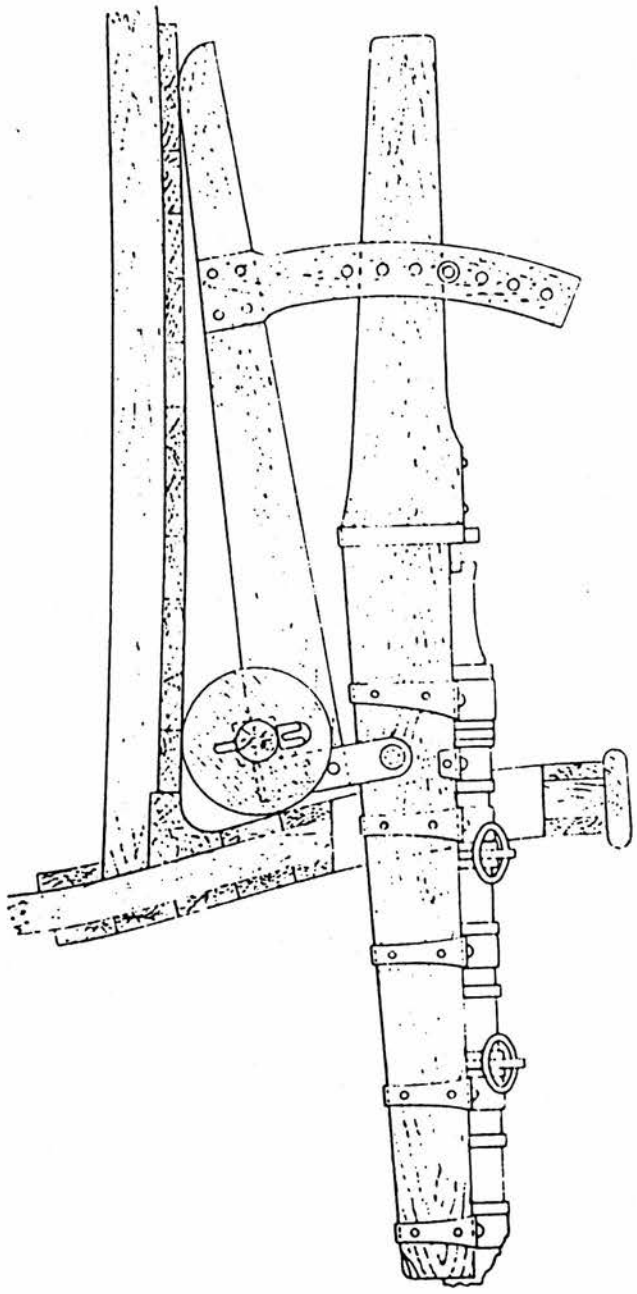

Poop
Somer / Upper
Nether / Middle
Barbican
Overlop
Orlop
Focsle

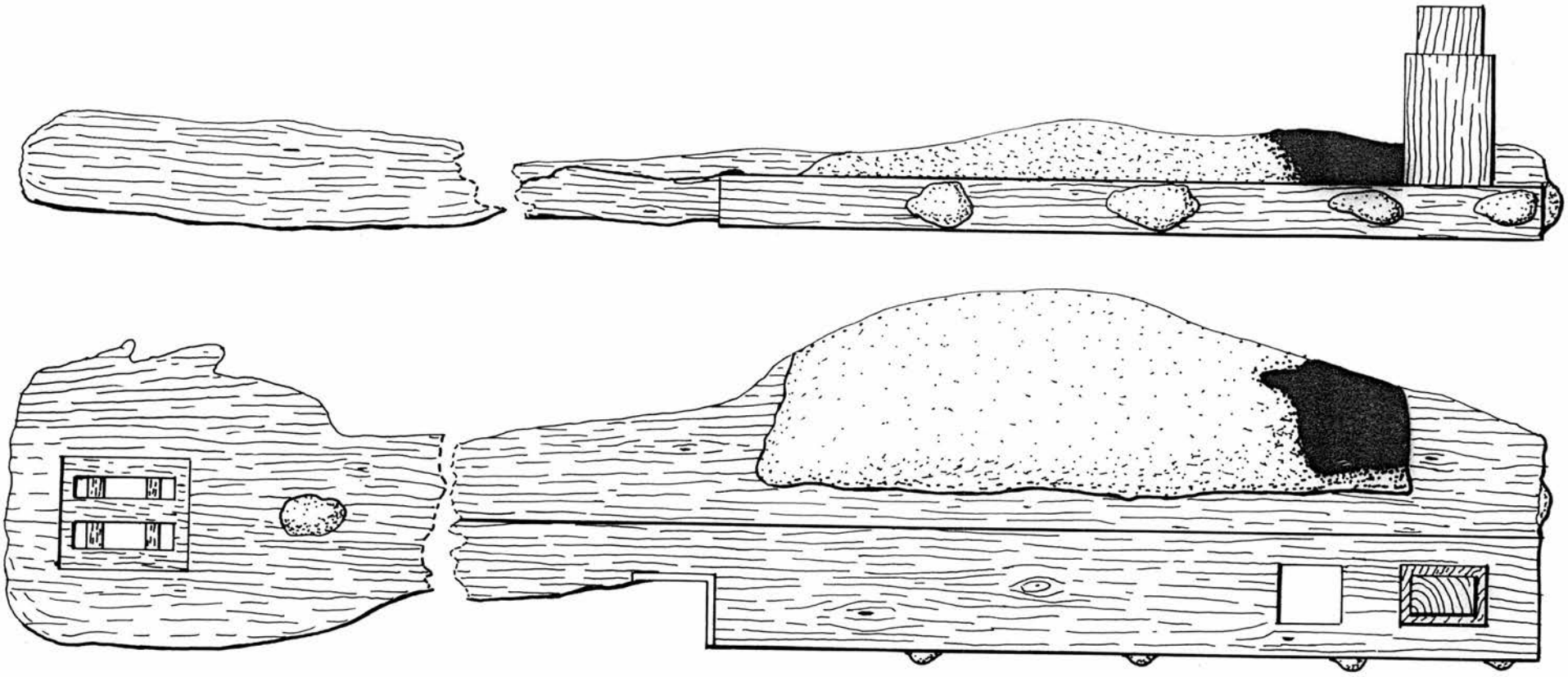

K
L
IAV.



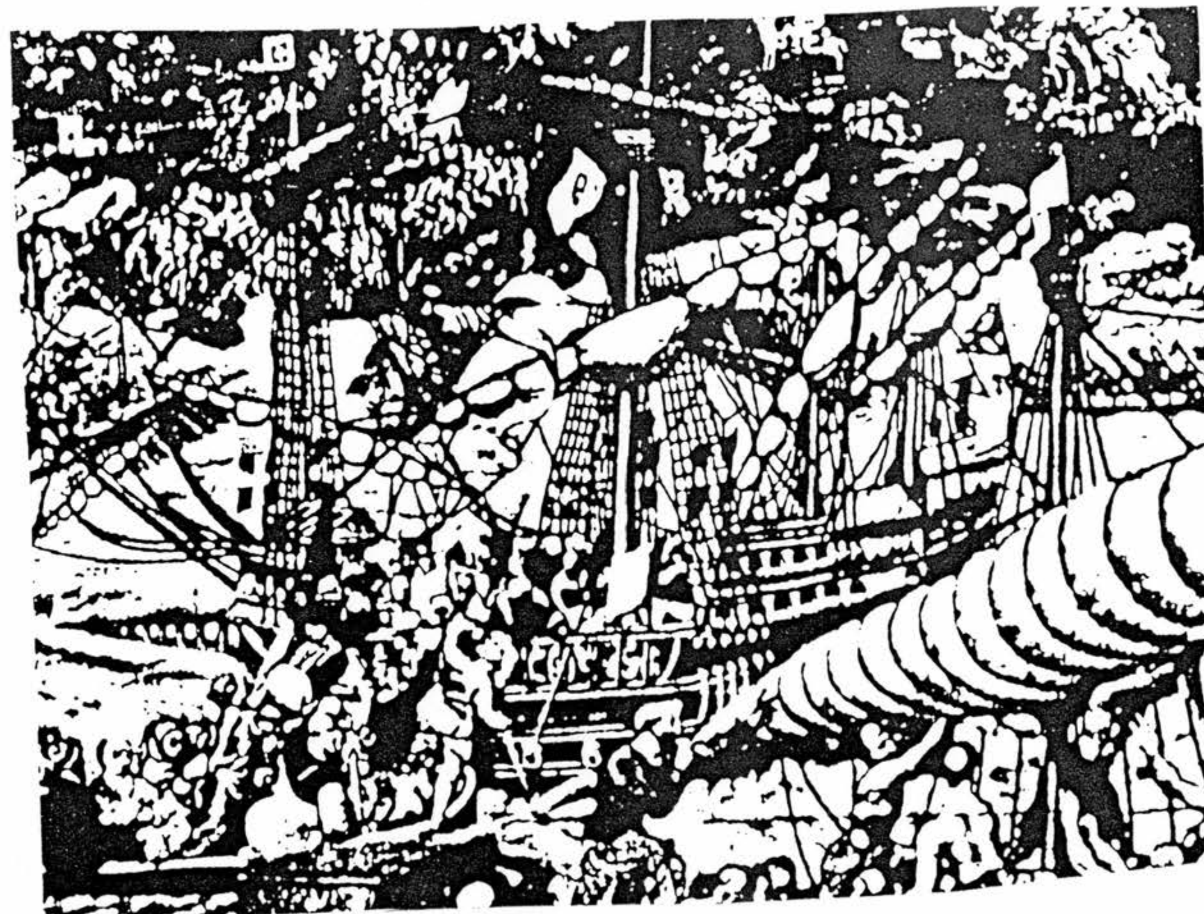

0 20 40 60 80 100 cm

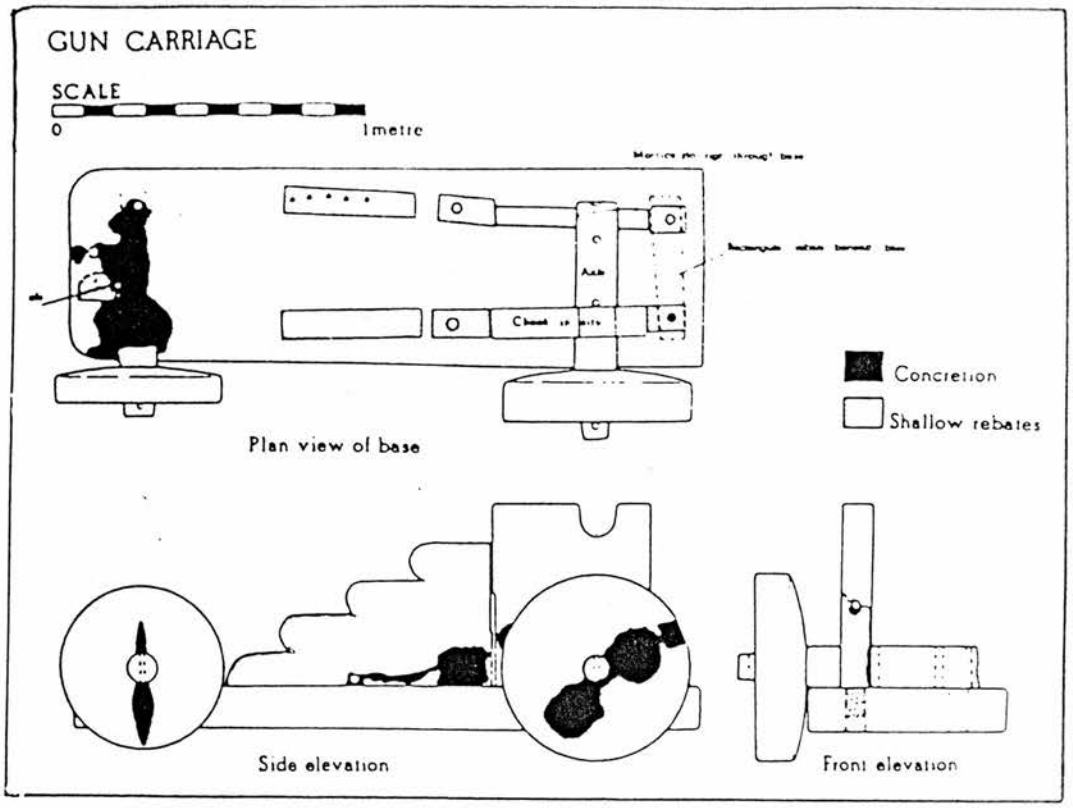


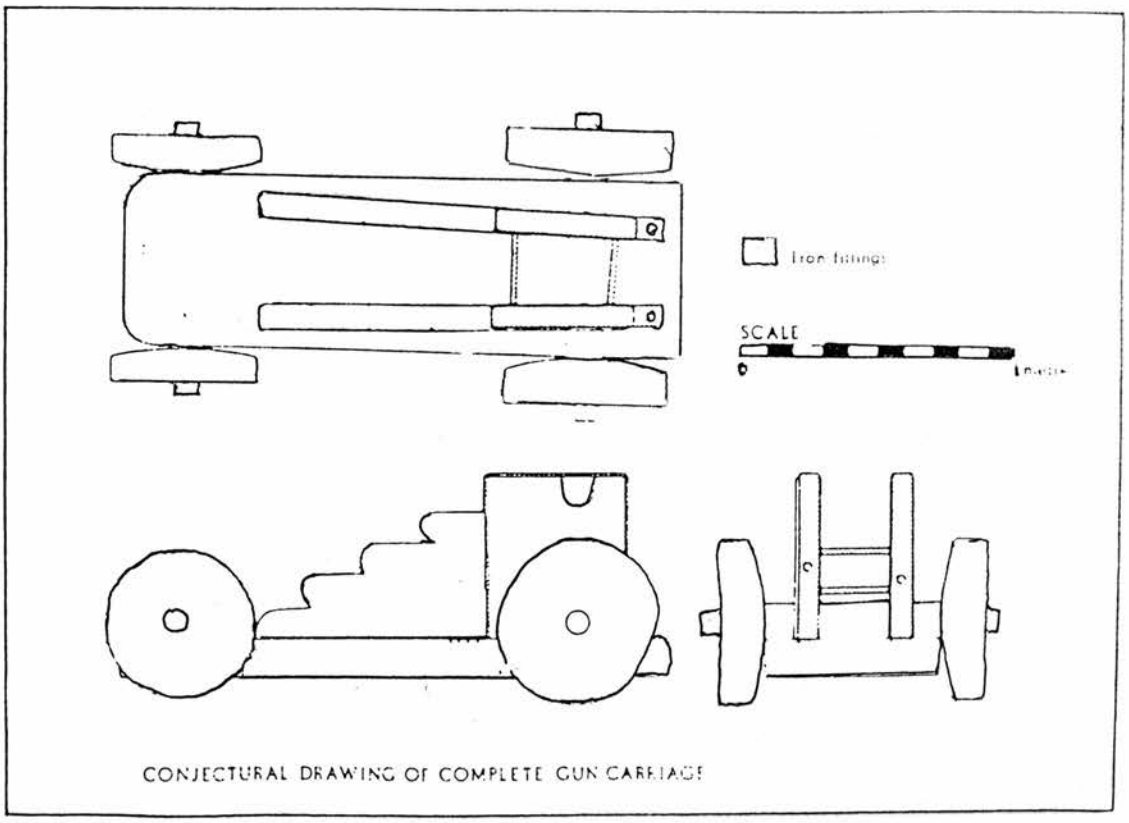


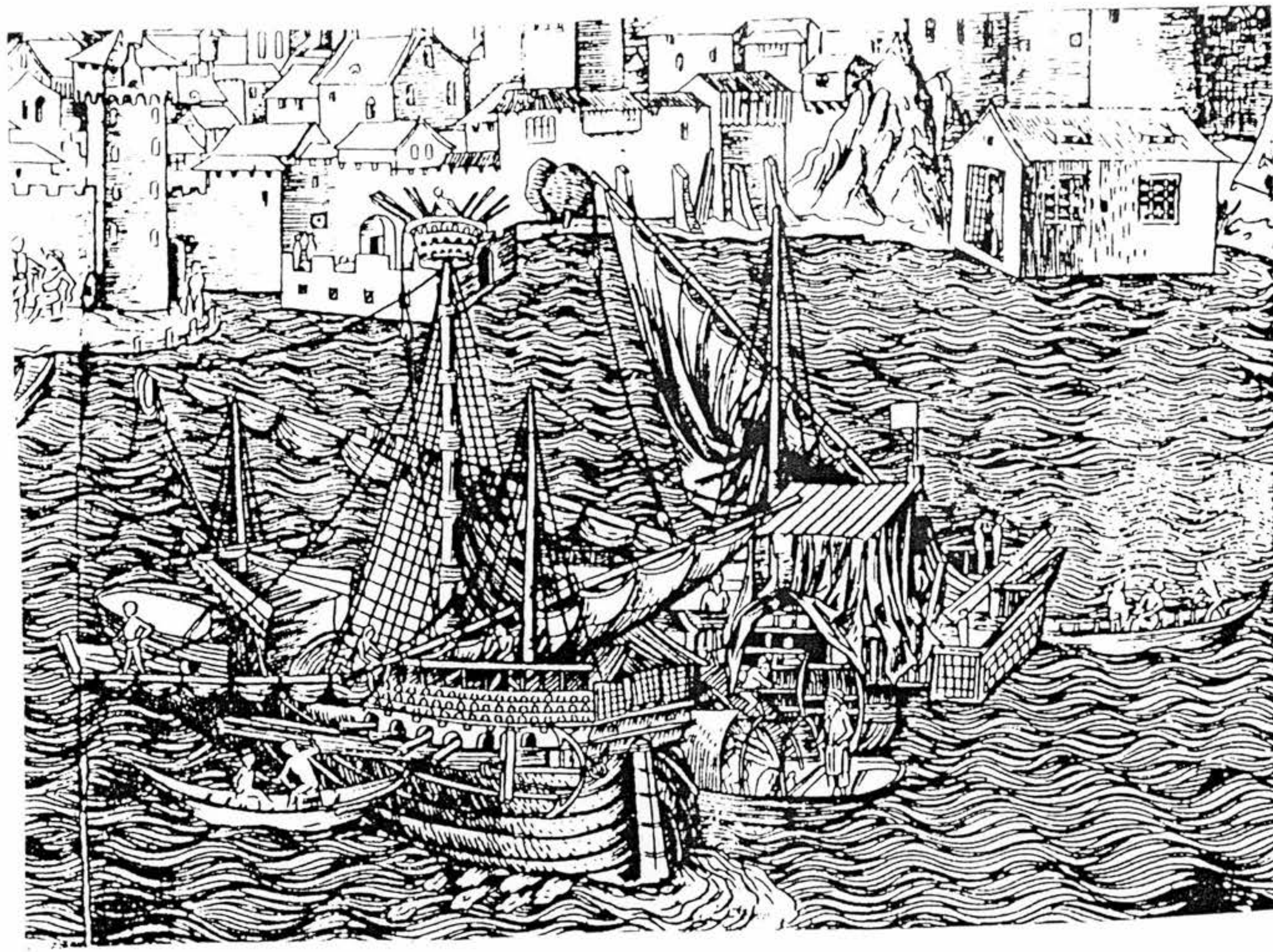


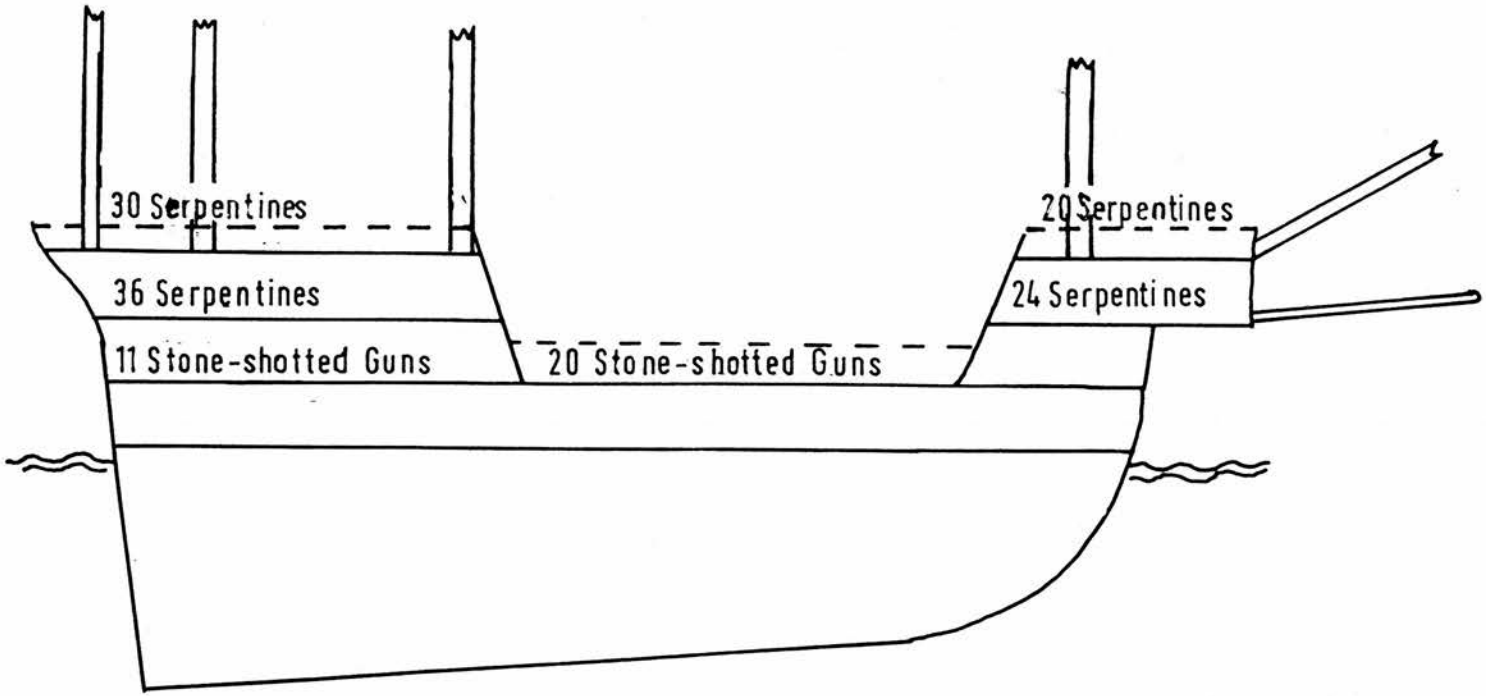
0 50 100
Centimetres

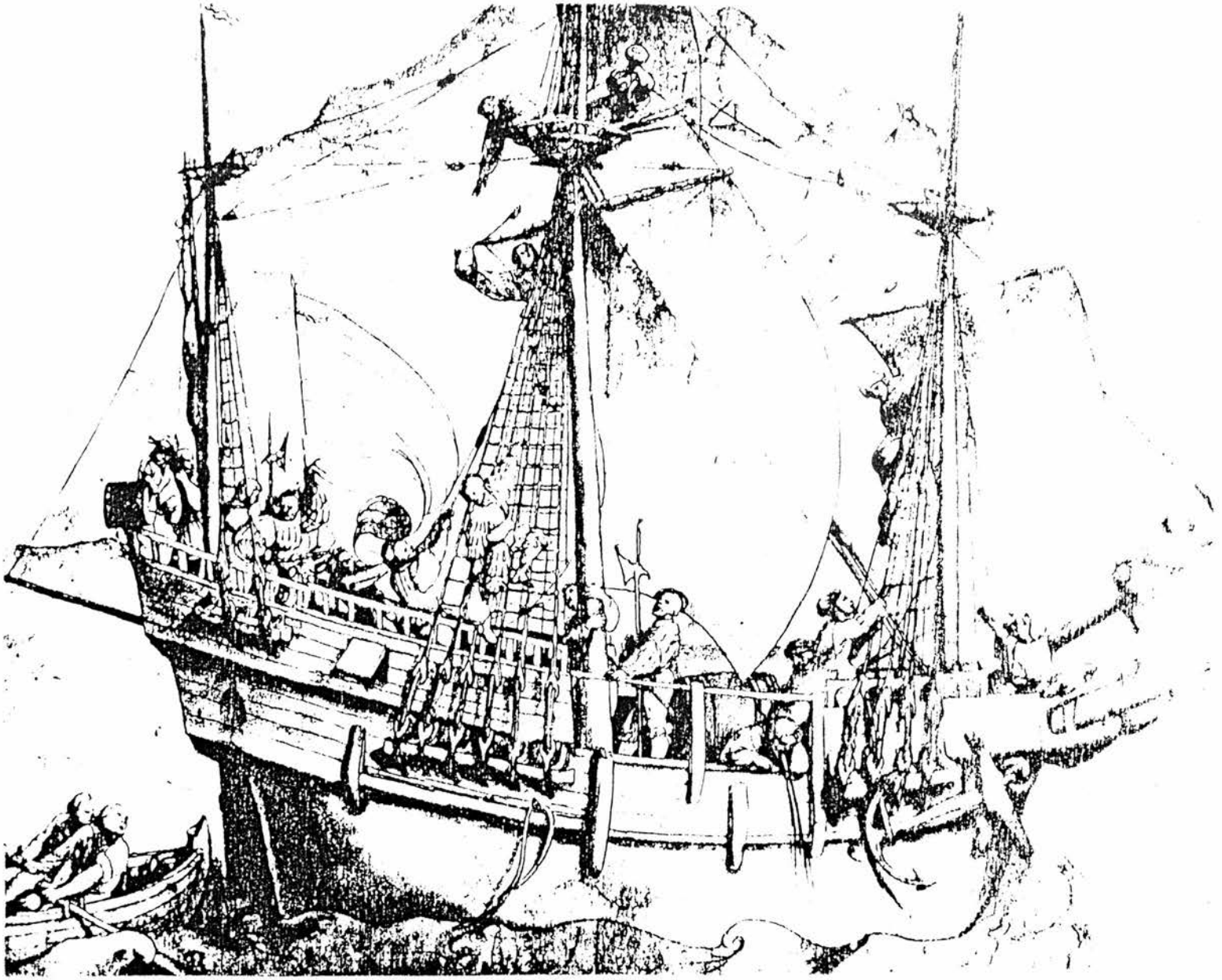


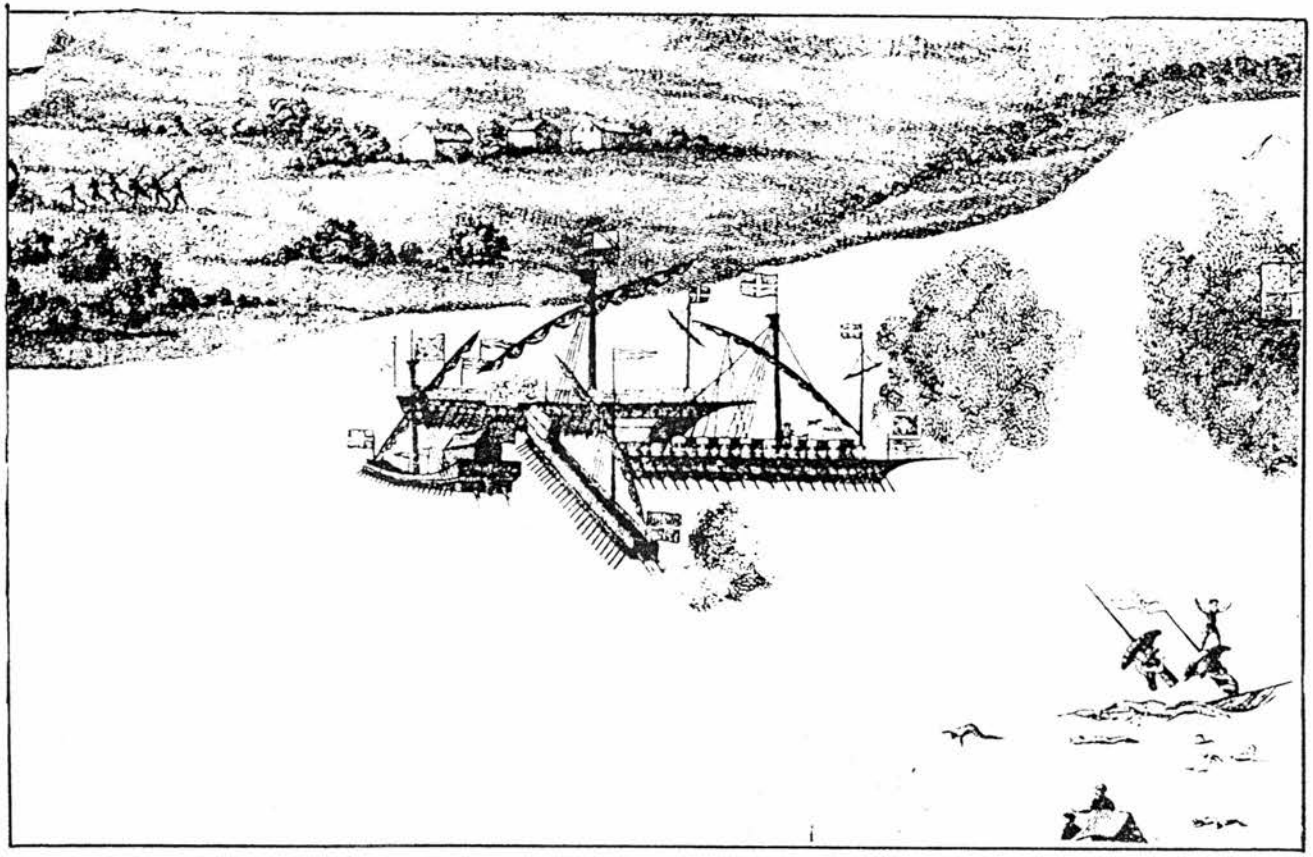

GUN CARRIAGE
SCALE
0
1metre
Concretion
Shallow rebates
Plan view of base
Side elevation
Front elevation

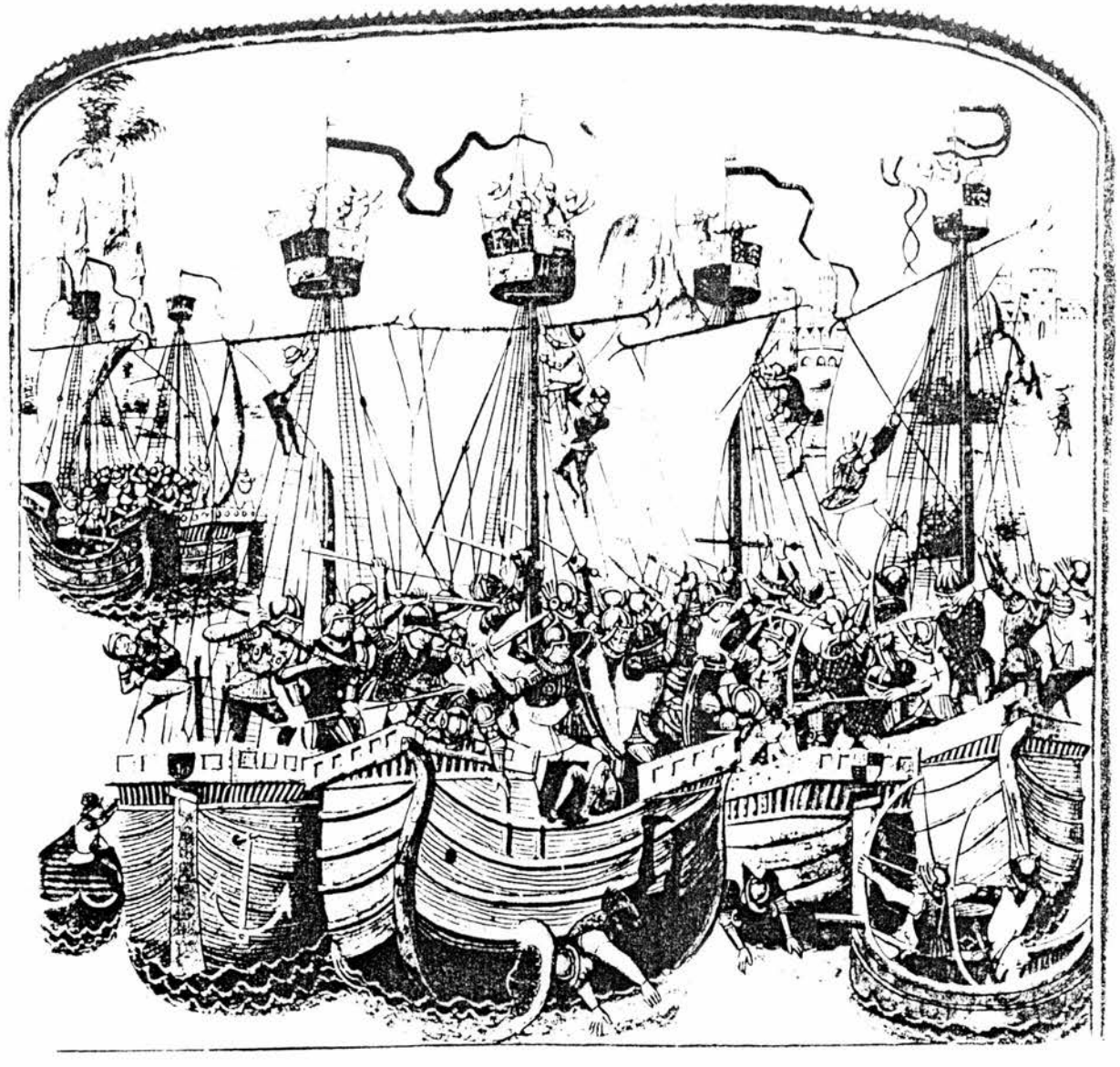

Iron fittings
SCALE
0
CONJECTURAL DRAWING OF COMPLETE GUN CARRIAGE

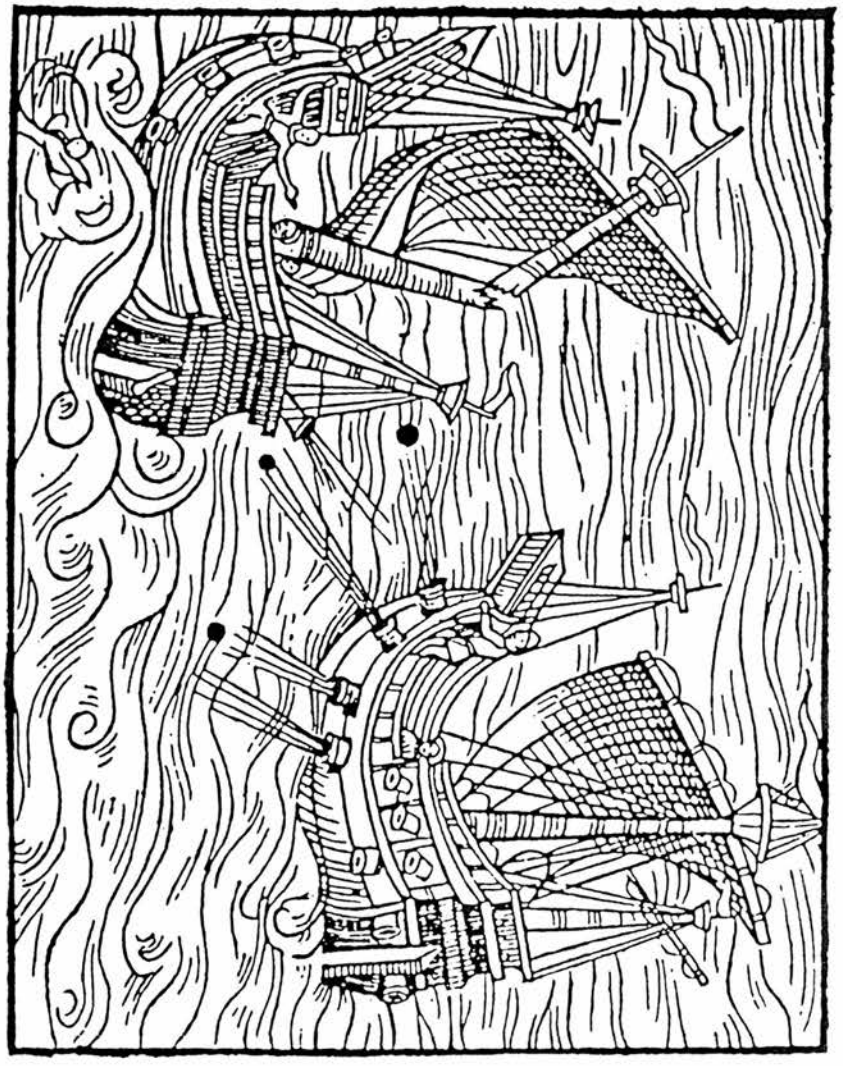


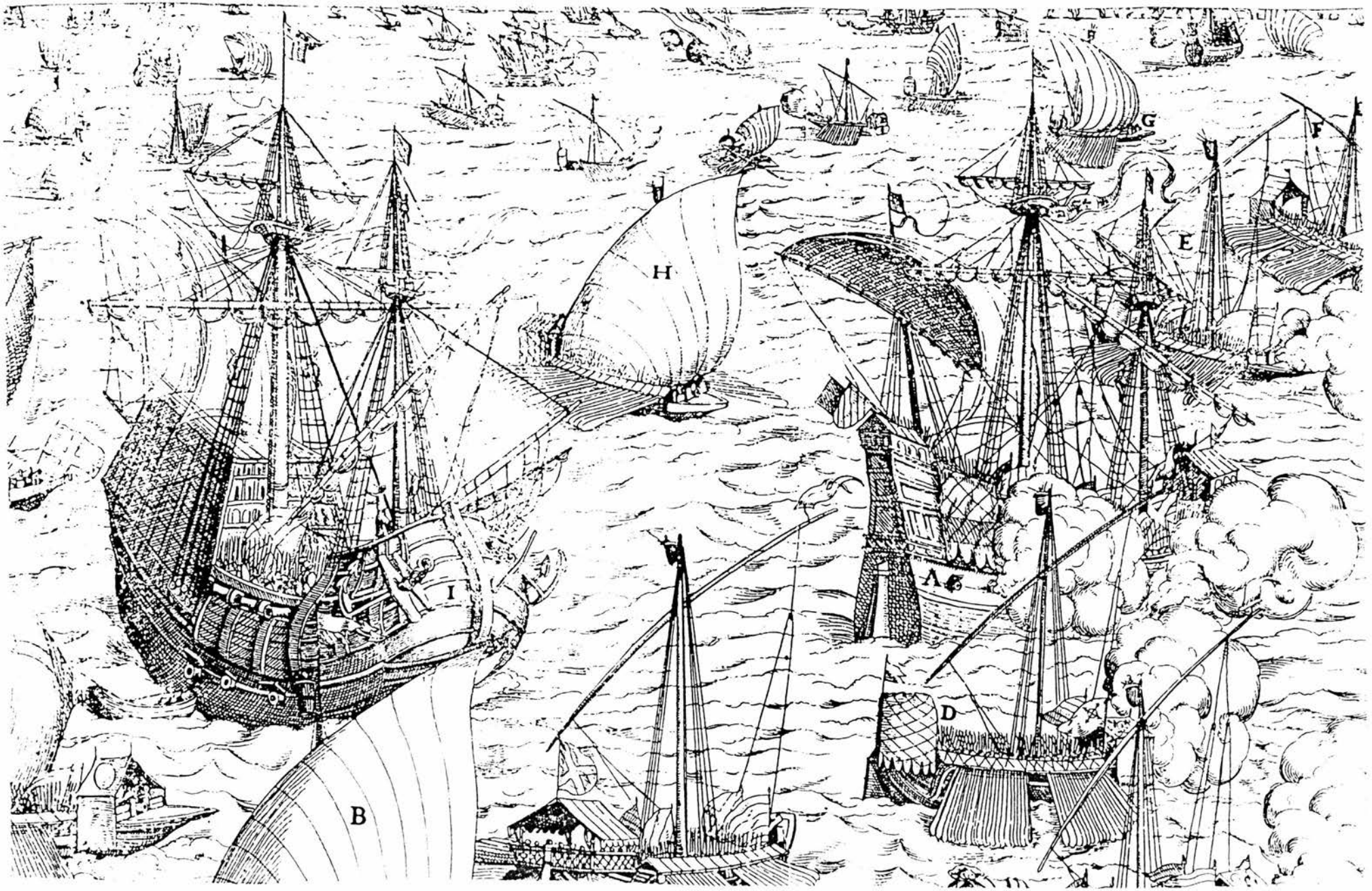

30 Serpentines
20 Serpentines
36 Serpentines
24 Serpentines
11 Stone-shotted Guns
20 Stone-shotted Guns










G
F
E
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A
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